Controls on reactive nitrogen inputs and exports in Central Valley watersheds

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Reactive Nitrogen Research for San Joaquin Valley Agriculture
June 4-5, 2013

Reactive N is a wicked problem

- Benefits from agricultural production:
  $2 to $5 per kg N
- Damage costs for human health:
  $0.54 to $39 per kg N
- Damage costs for ecosystems/climate:
  -$12 (benefit) to $56 per kg N

Enhanced crop yields

Products & Energy

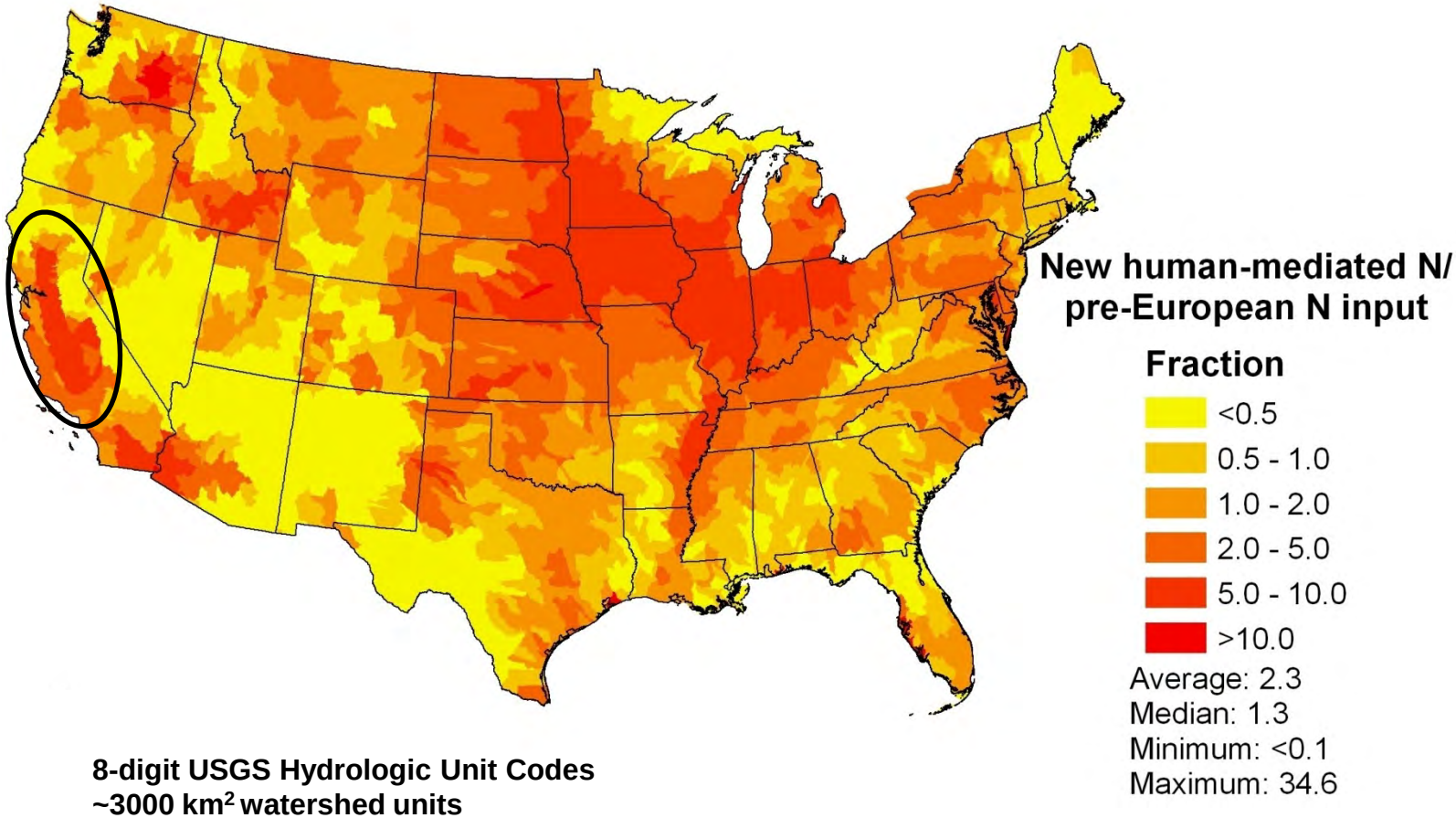
Drinking water contamination

Smog formation

Harmful Algal Blooms & Hypoxia

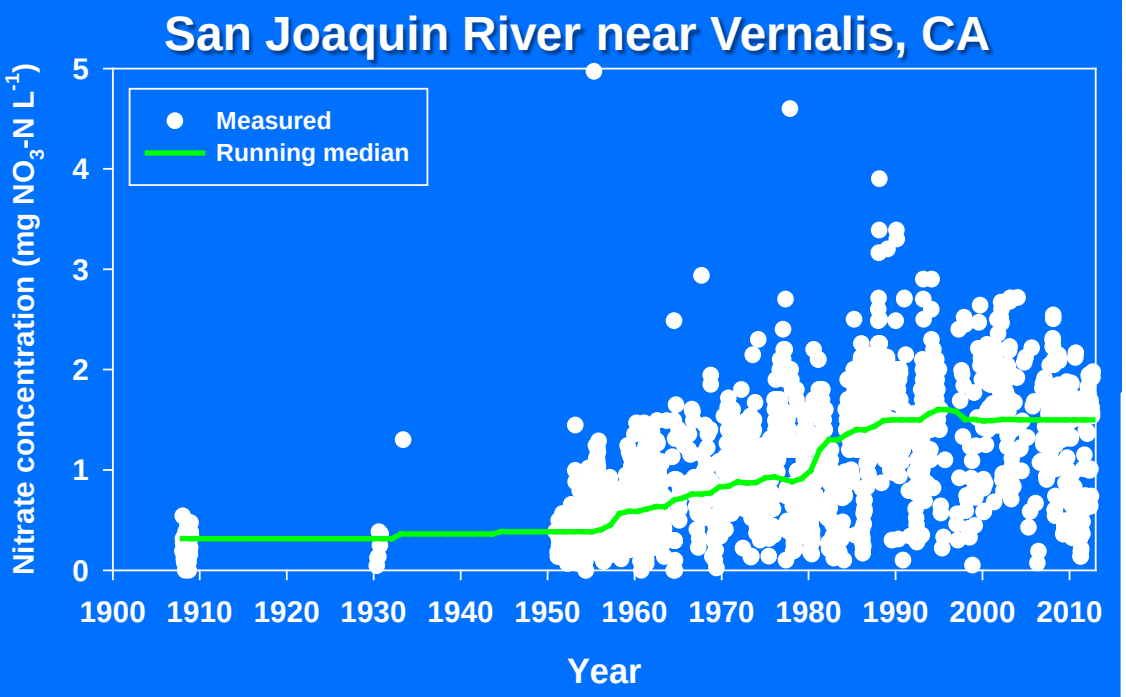
Cost estimates from Compton et al. (2011) and Van Grisman et al. (2013)

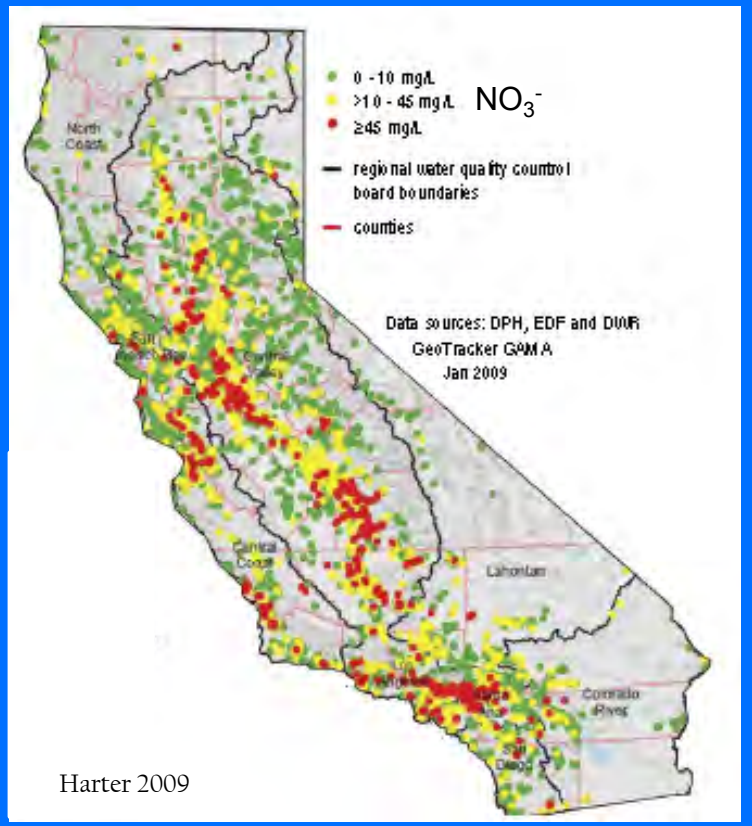
Human imprint on N inputs in the United States



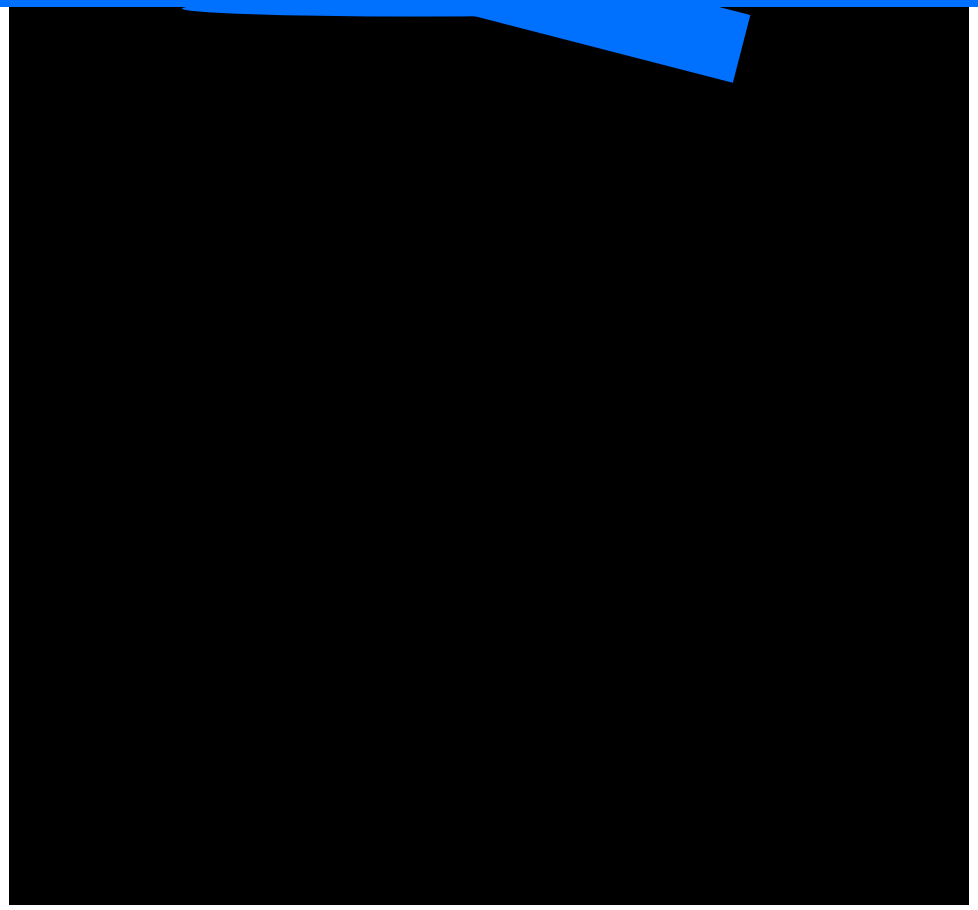
Sobota et al. 2013, Frontiers in Ecology and the Environment

Central Valley water quality issues





The Central Valley as a study system for reactive N



The Central Valley as a study system for reactive N

1. Environmental diversity

National Elevation Dataset

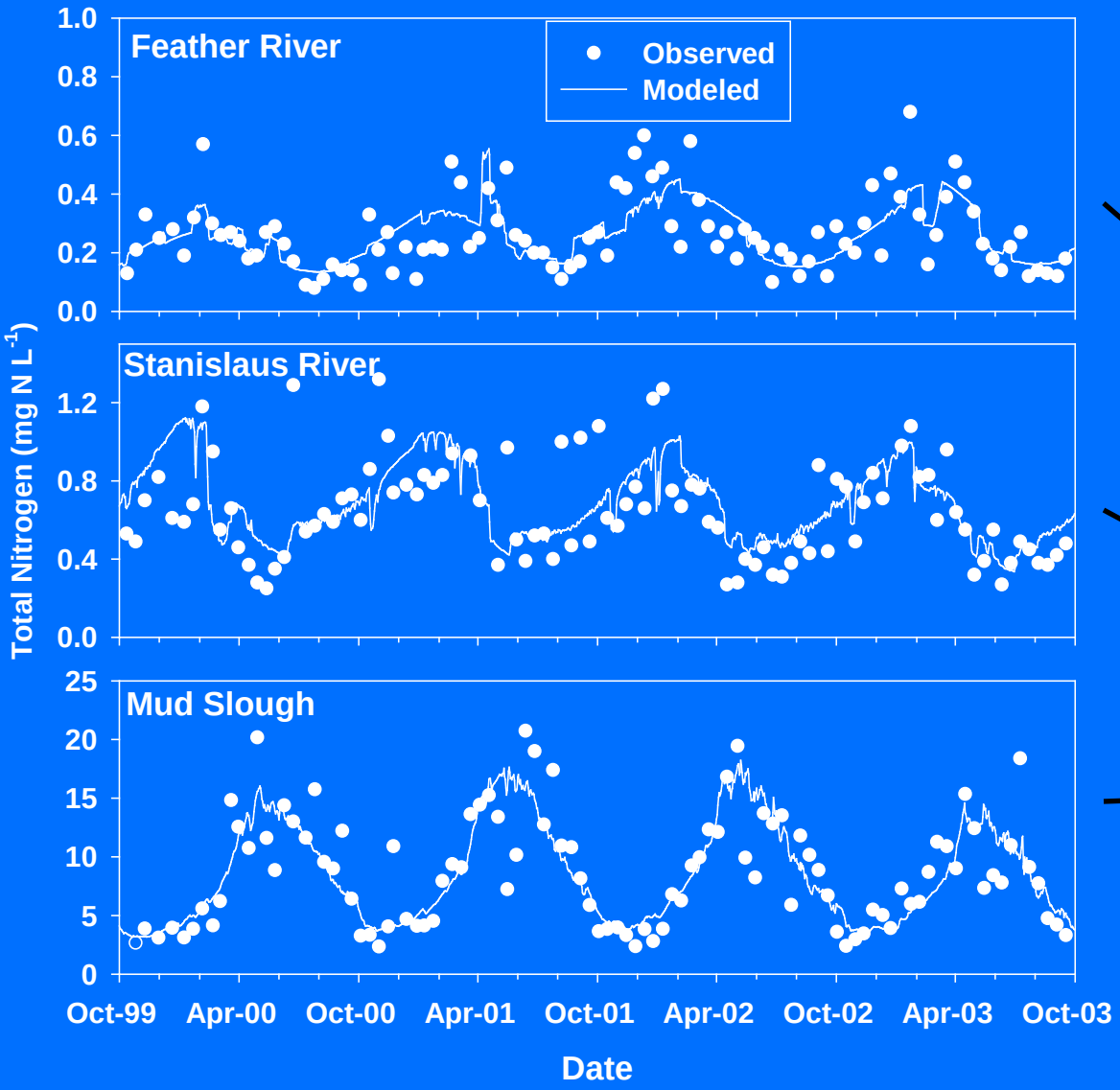
PRISM

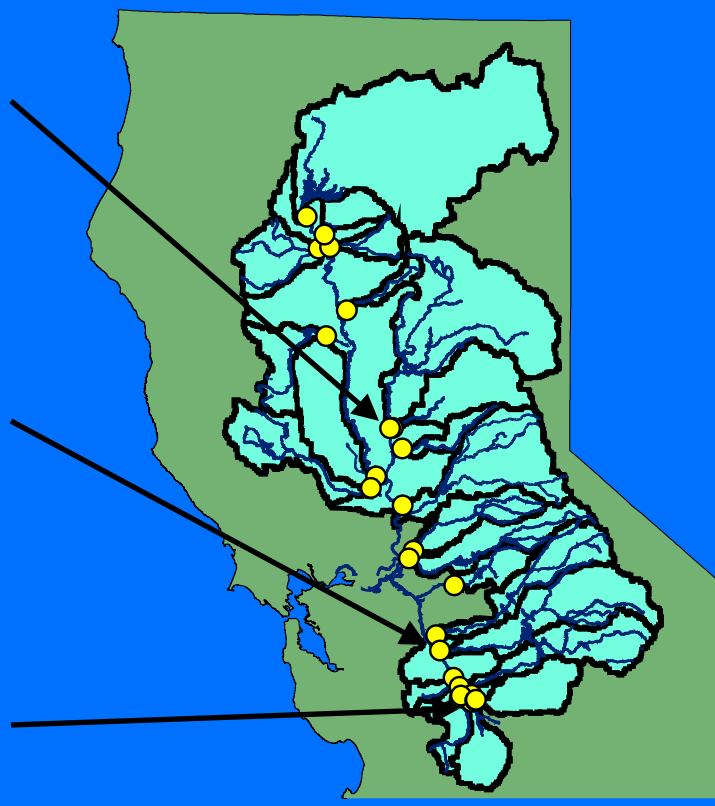
LCMMP

2. Diverse land use/land cover

76 distinct land use/land cover and crop classes!

3. Data on riverine N export





Talk objectives

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- Provide estimates of anthropogenic reactive N inputs by source to Central Valley watersheds

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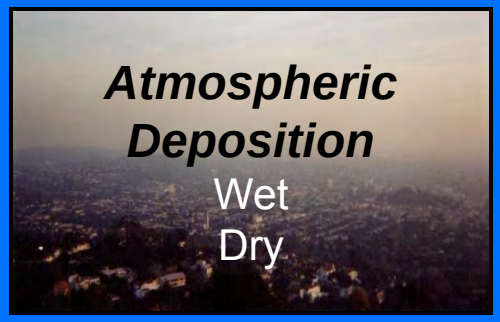
- Provide estimates of anthropogenic reactive N inputs by source to Central Valley watersheds
- Examine landscape factors that might influence riverine exports of reactive N
- Describe new work examining current and future riverine export of dissolved inorganic N in the San Joaquin River

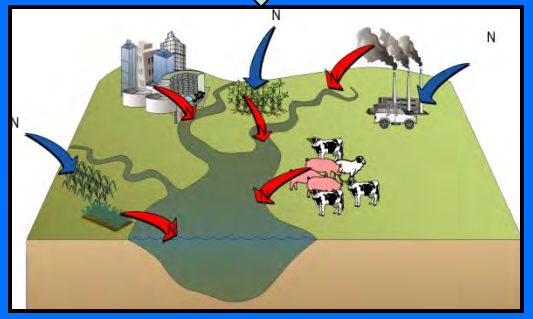
Anthropogenic inputs of reactive N to watersheds

Definitions

- Inputs & yields: mass per area per time
  - kg N km^{-2} yr^{-1} ≈ lbs N $acre^{-1}$ yr^{-1} * 100
- Loads: mass per time
  - kg N yr^{-1} = 2.2 lbs N yr^{-1}
- Concentration: mass per volume of water
  - mg N L^{-1}
- Runoff: volume of water per area per time
  - mm yr^{-1} = 0.04 inches yr^{-1}

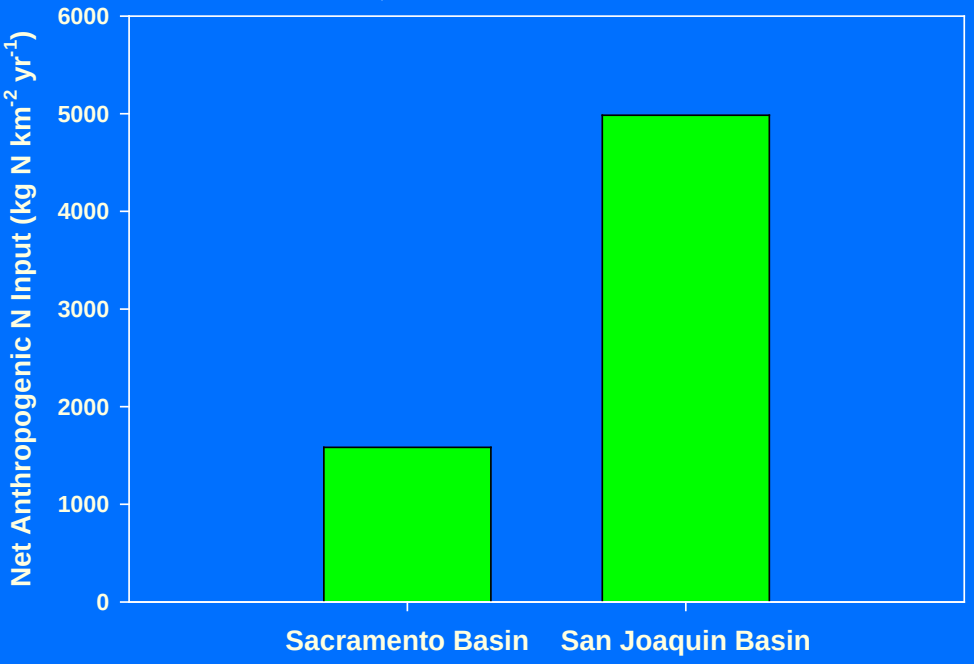
Net N inputs from human activities late 1990s - early 2000s



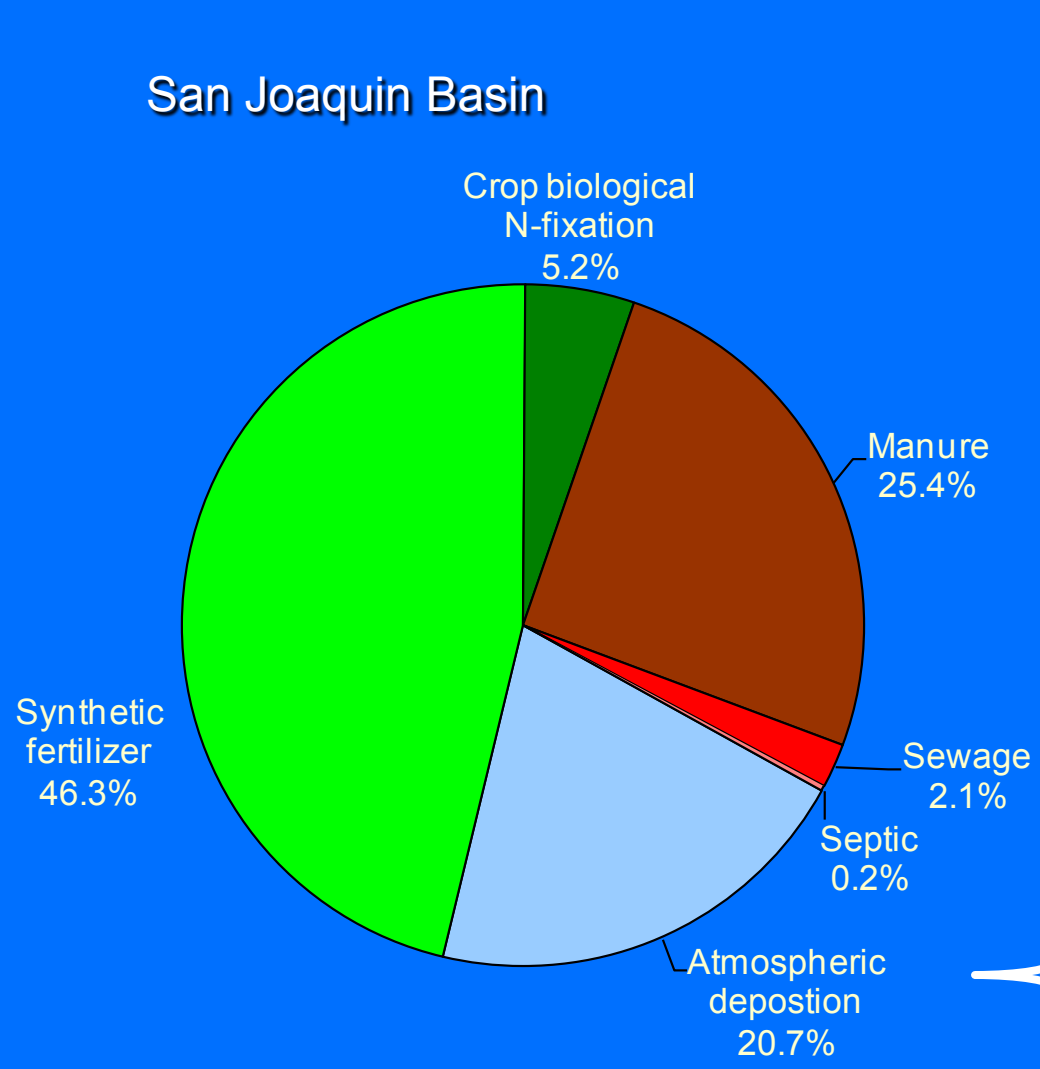


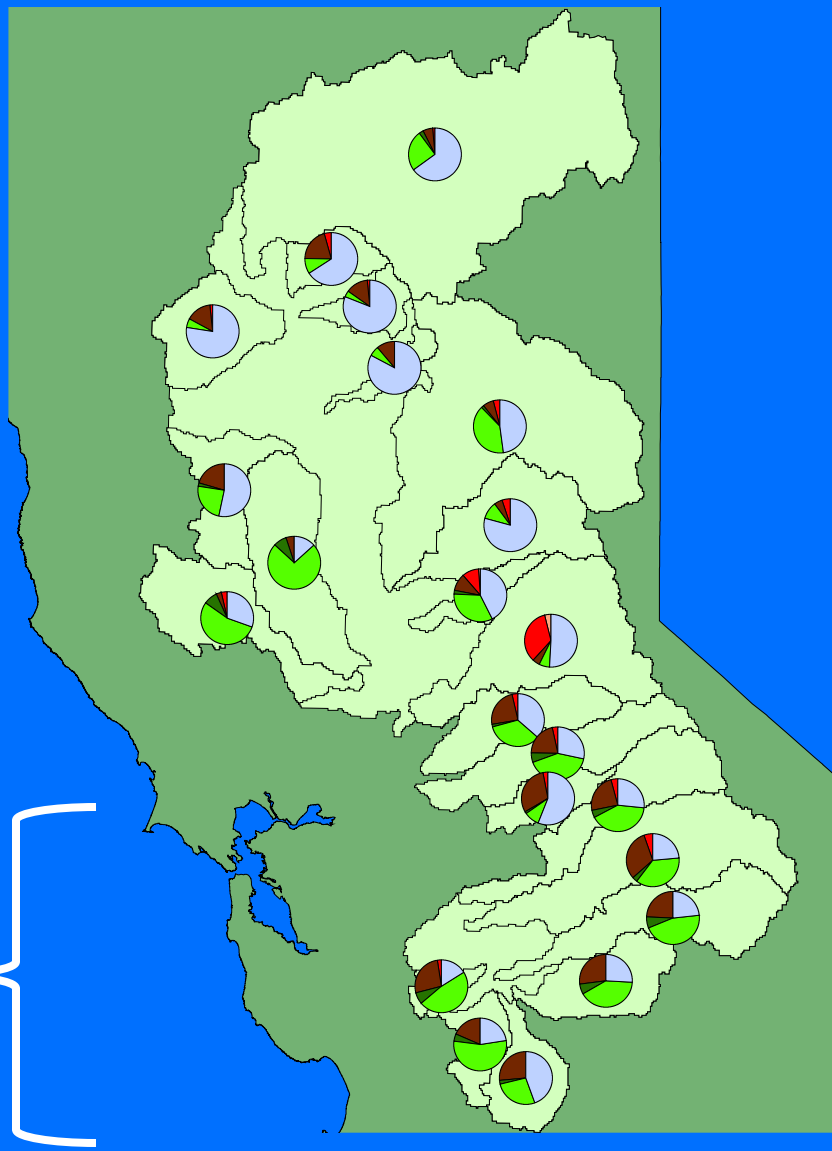
Sobota et al. 2009, Biogeochemistry
Sobota et al. 2011, Journal of Environmental Quality

Net anthropogenic N input – early 2000s



Watershed N inputs by source





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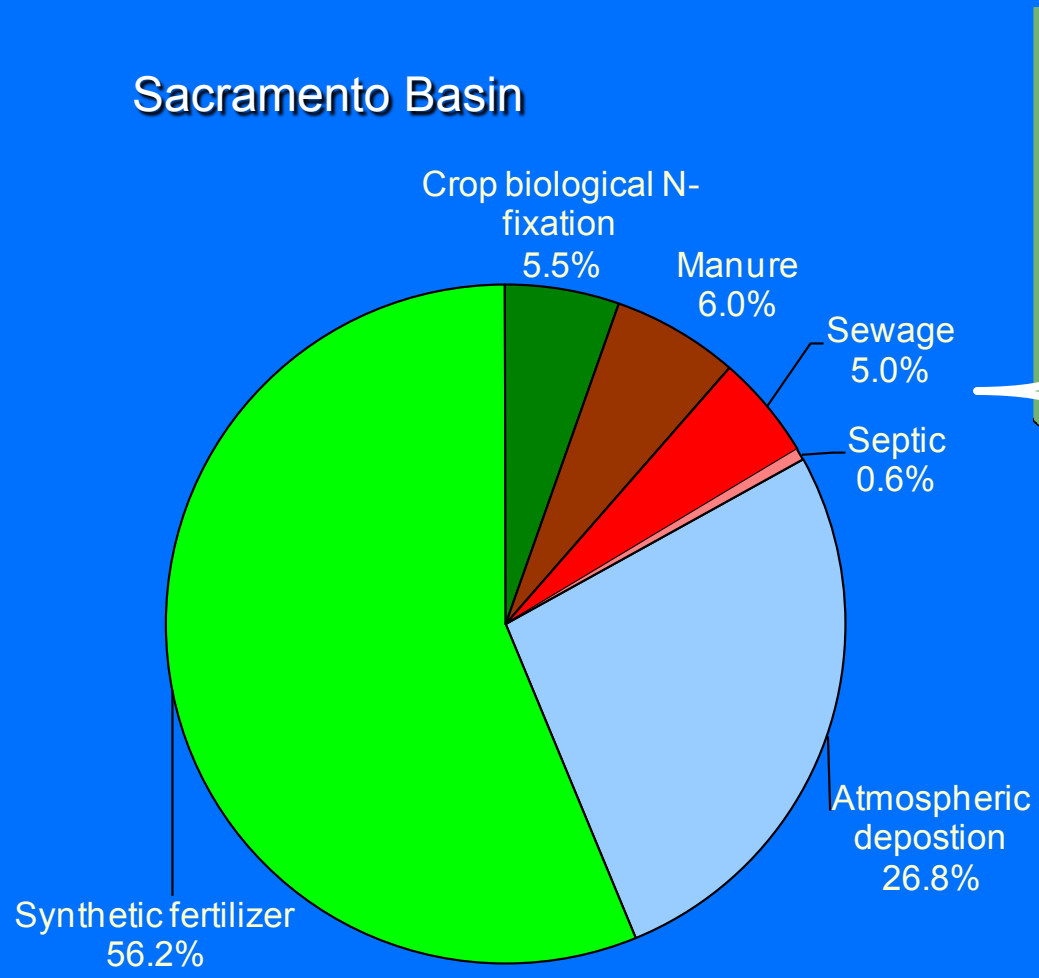
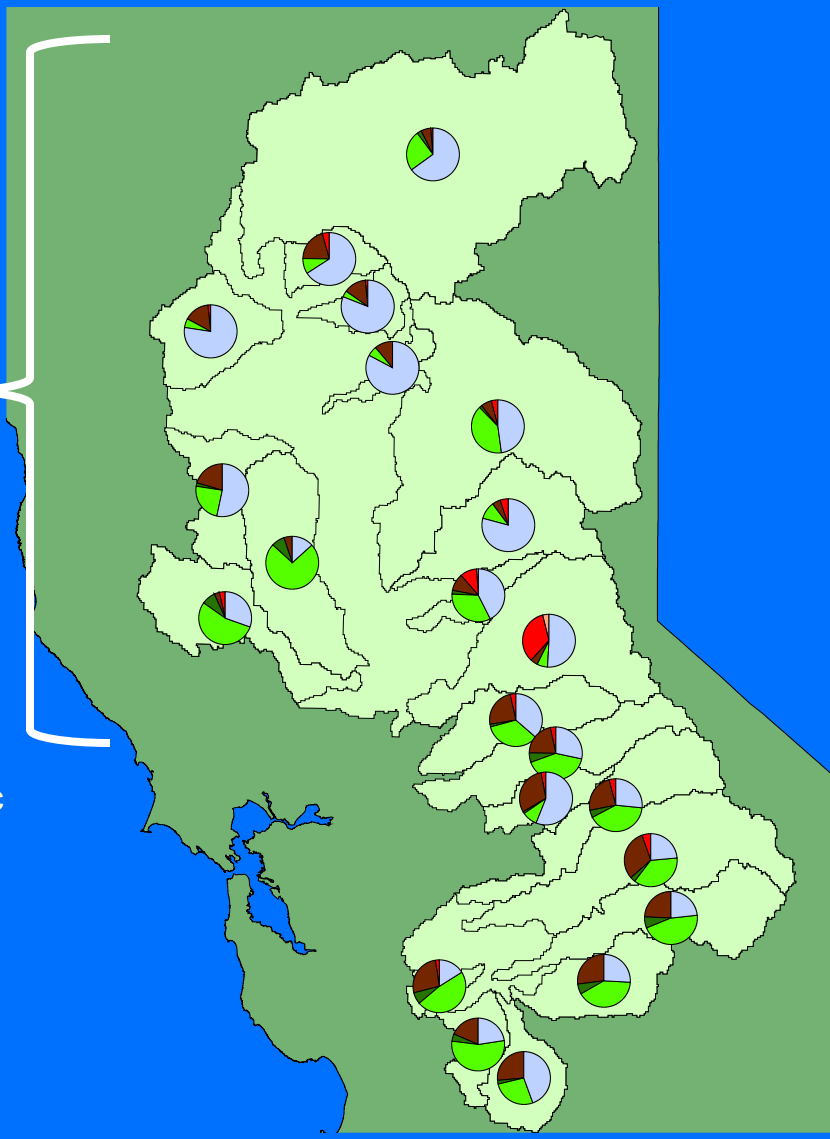




Atmospheric N deposition - 2002

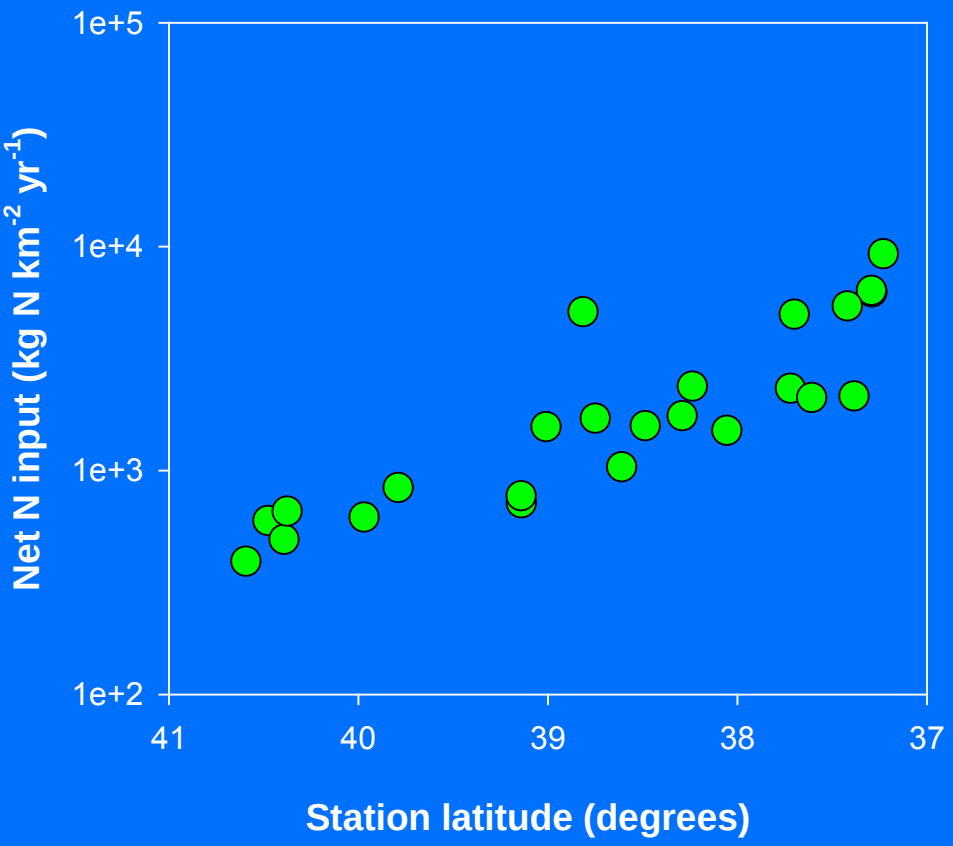
Manure inputs - 1997

Synthetic N fertilizer – 1999-2001

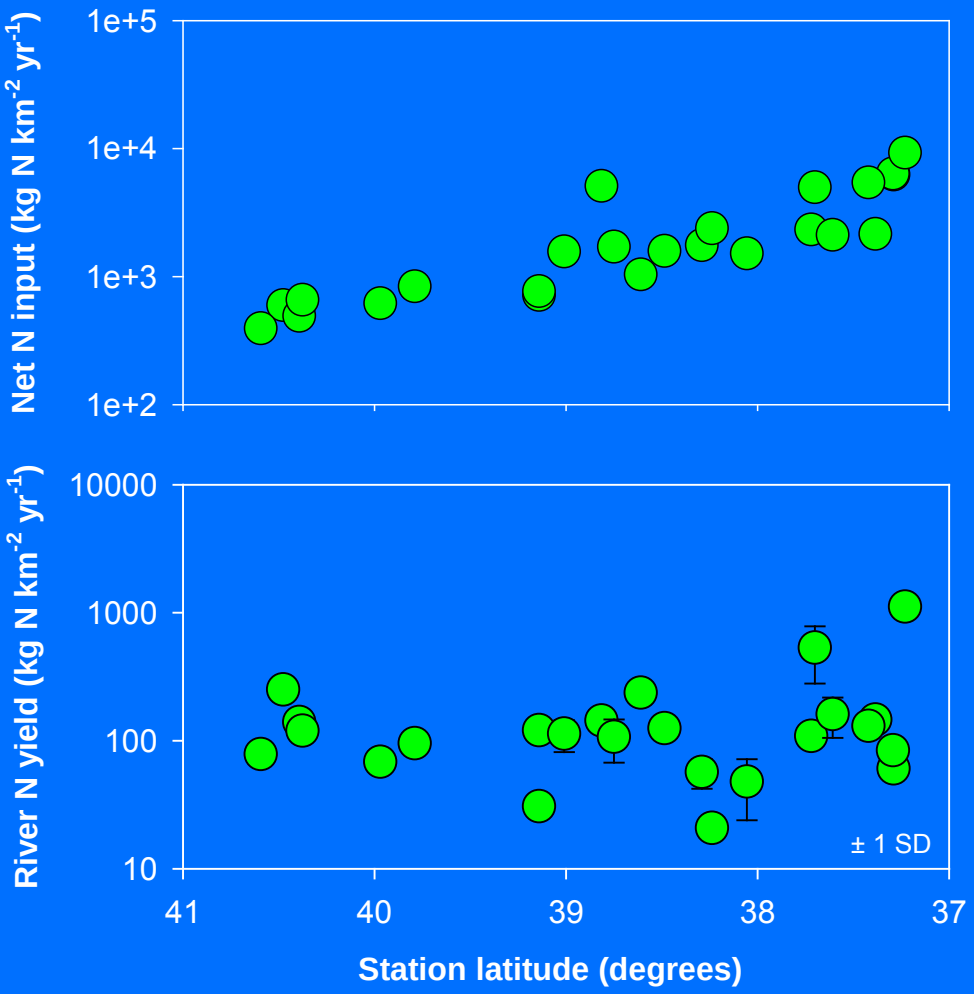
10 – 29% of synthetic fertilizer accounted in harvest

Factors influencing riverine N export

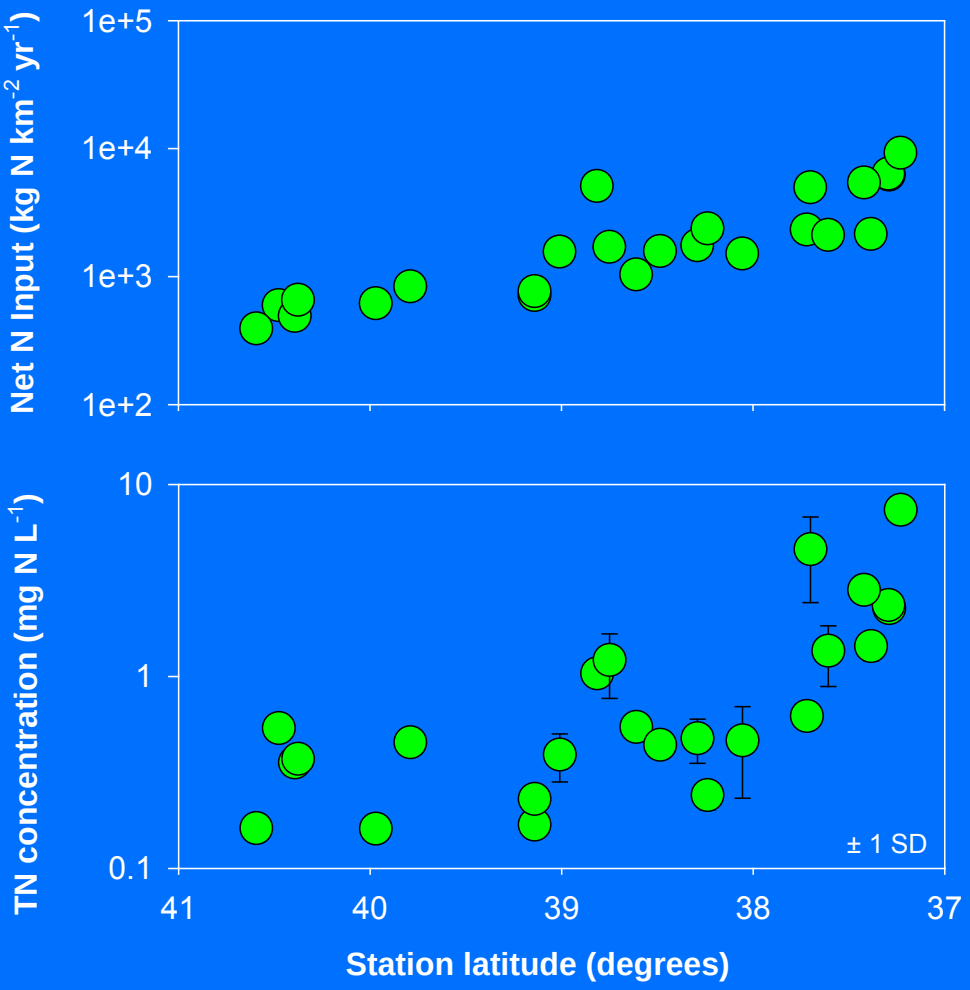
Spatial pattern – inputs



Spatial pattern - yields



Spatial pattern - concentrations



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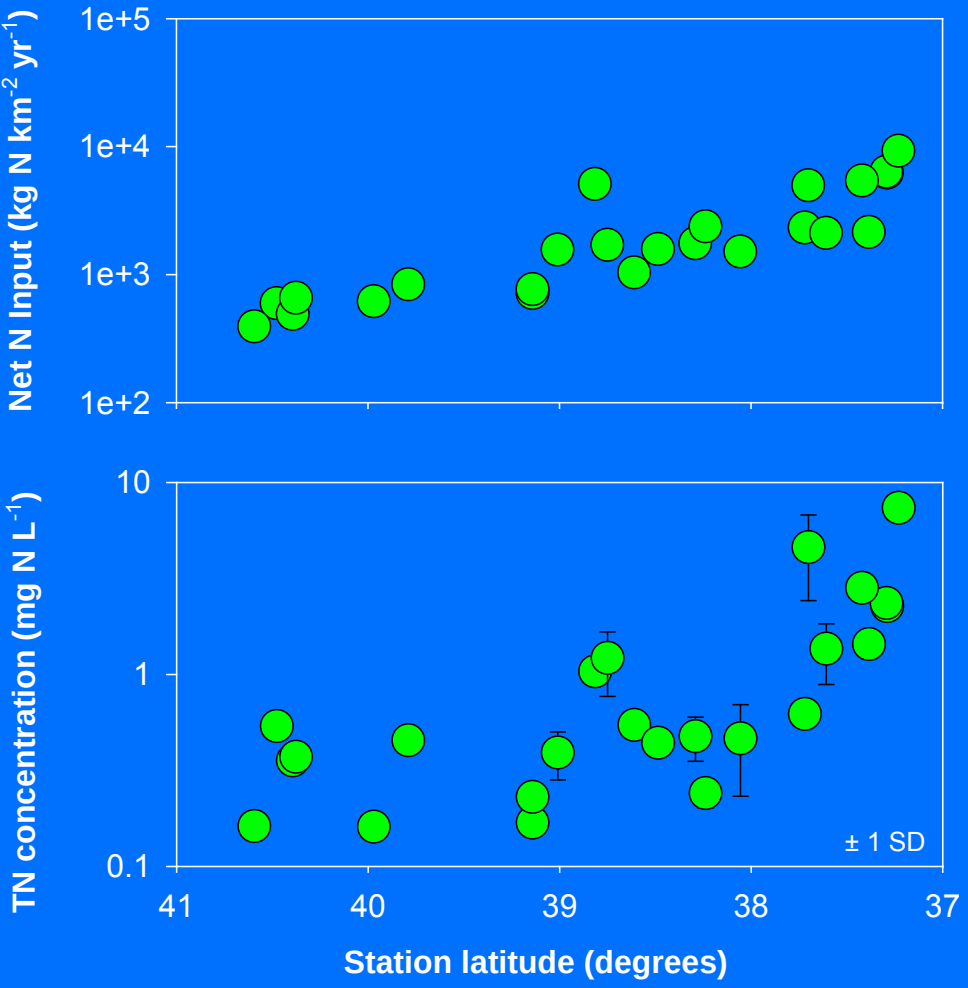
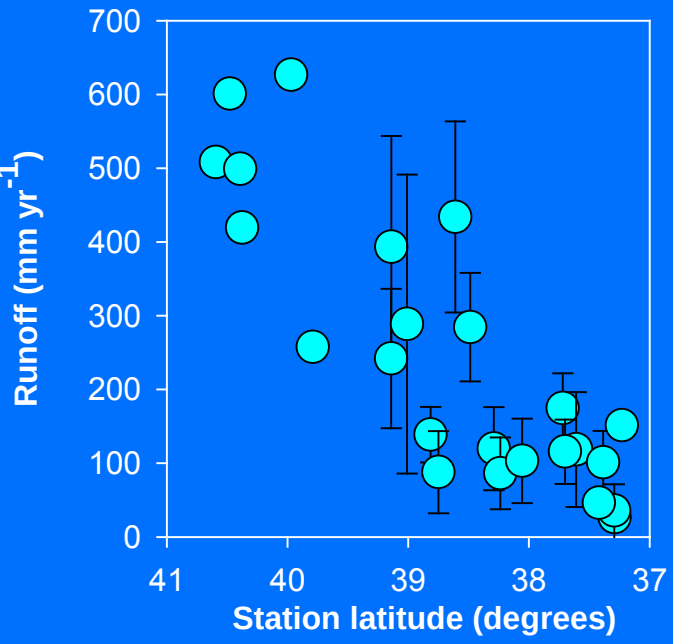
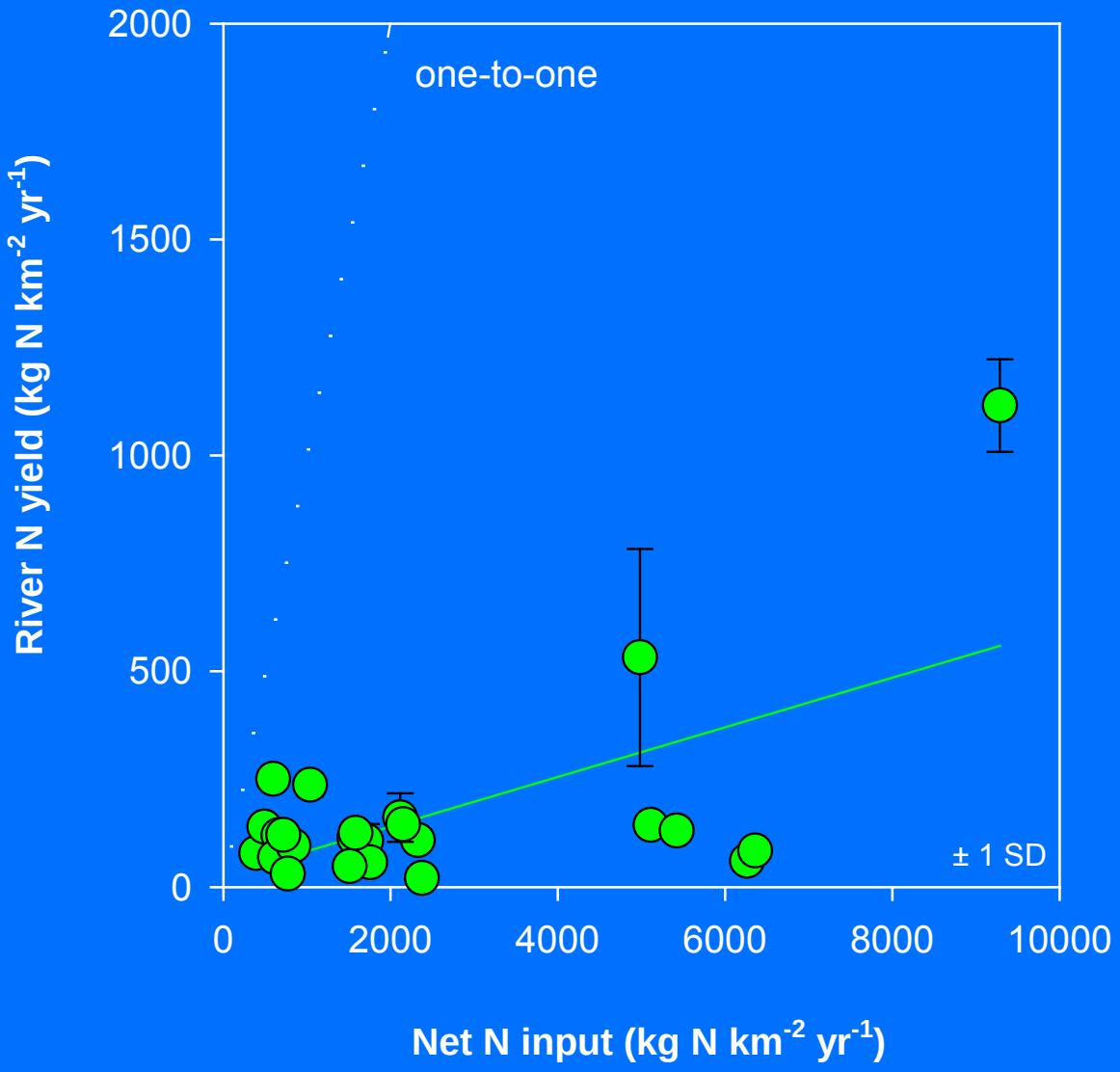




Net N inputs & runoff explain 72% of variance in TN concentrations

Input – yield comparisons



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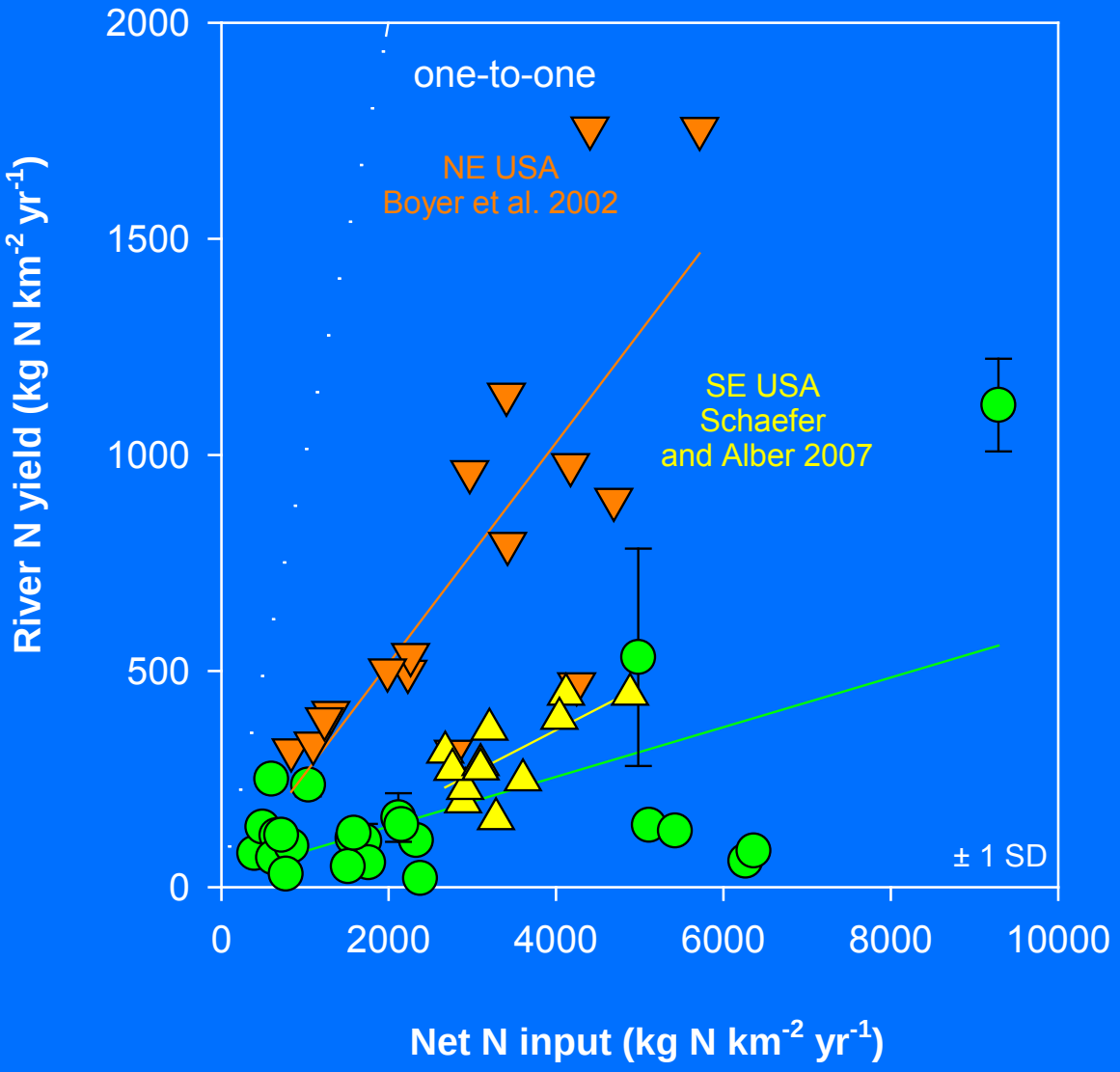
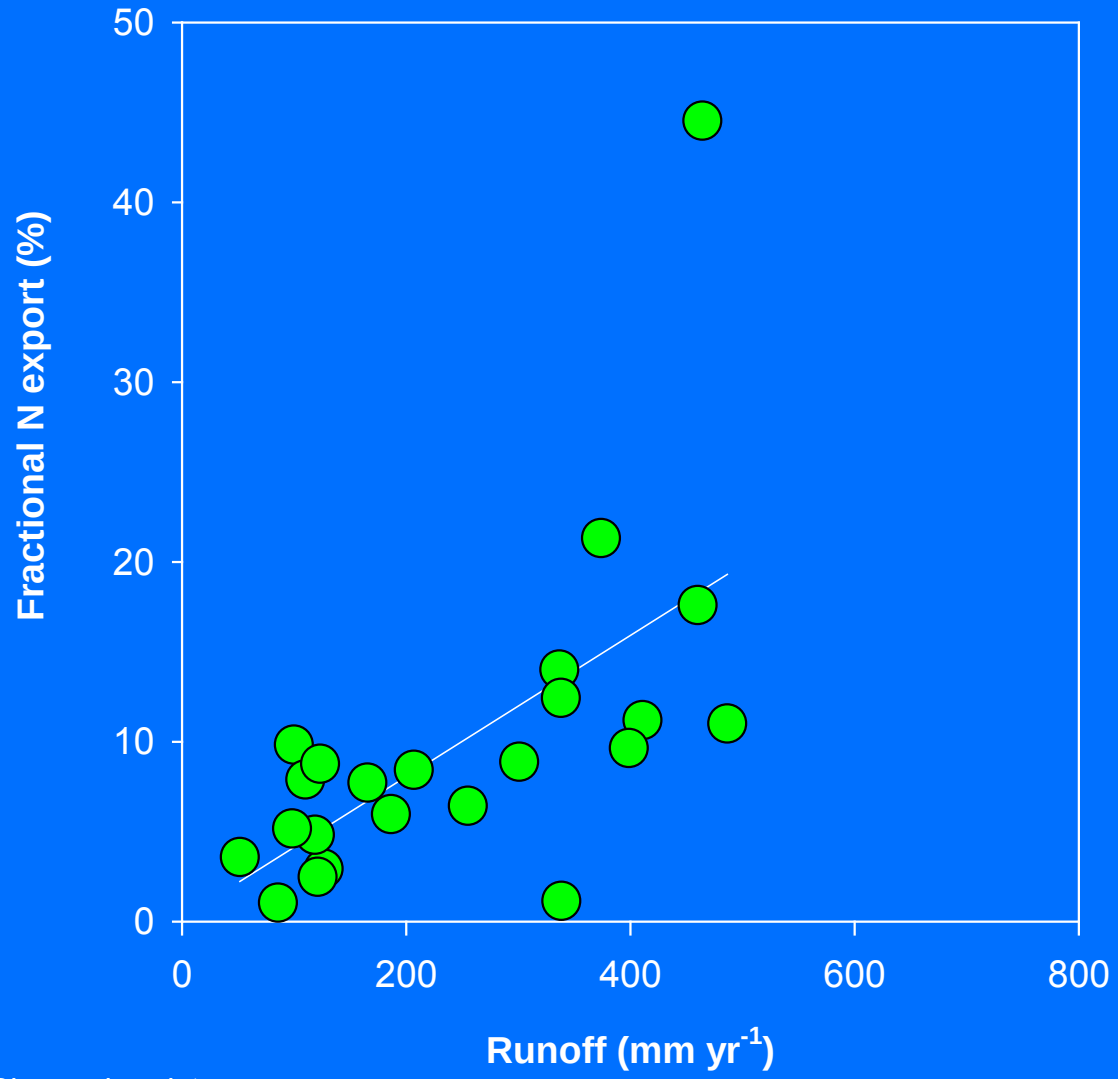


Fractional export of N inputs



Sobota et al. (2009), Biogeochemistry

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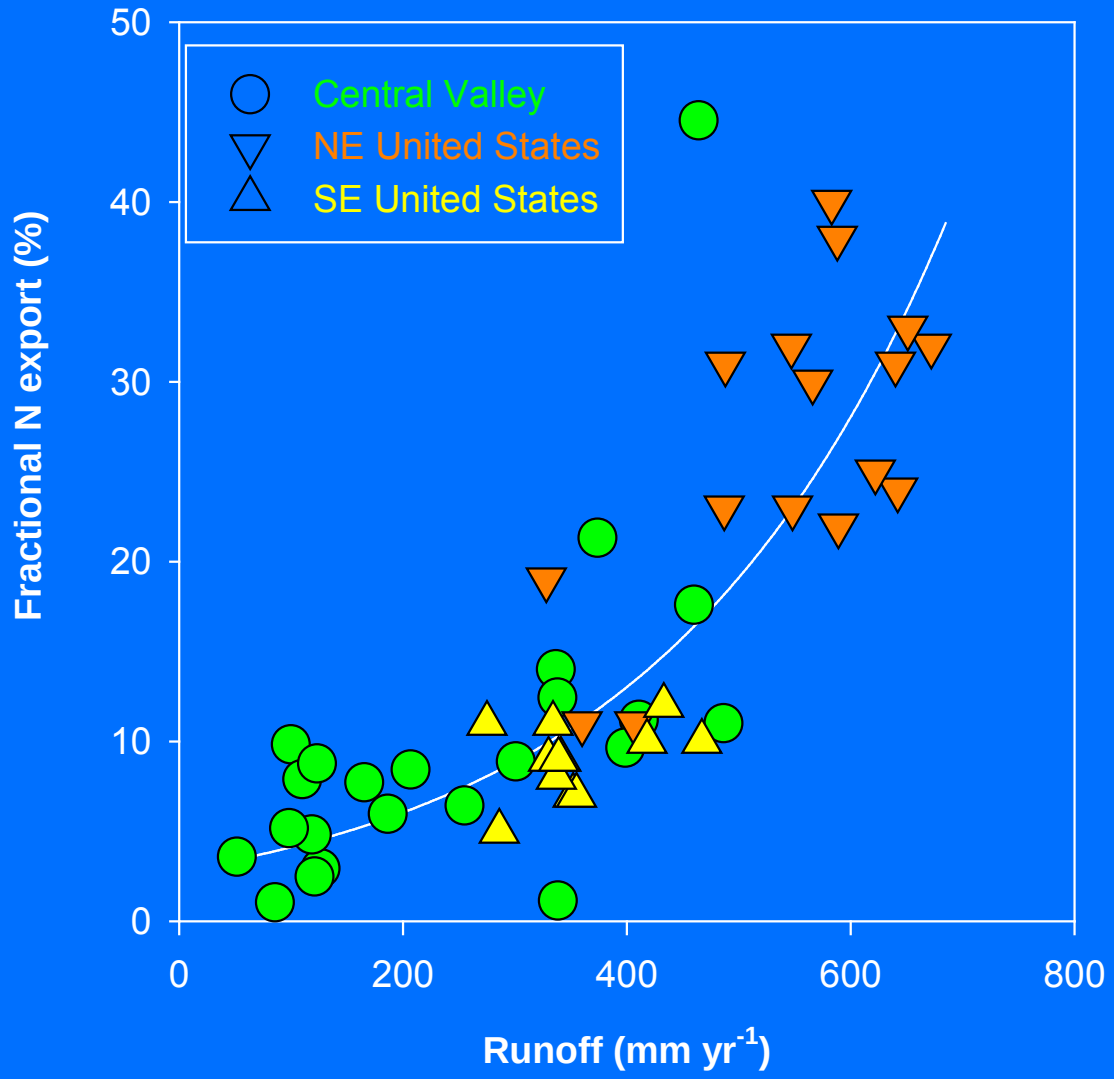
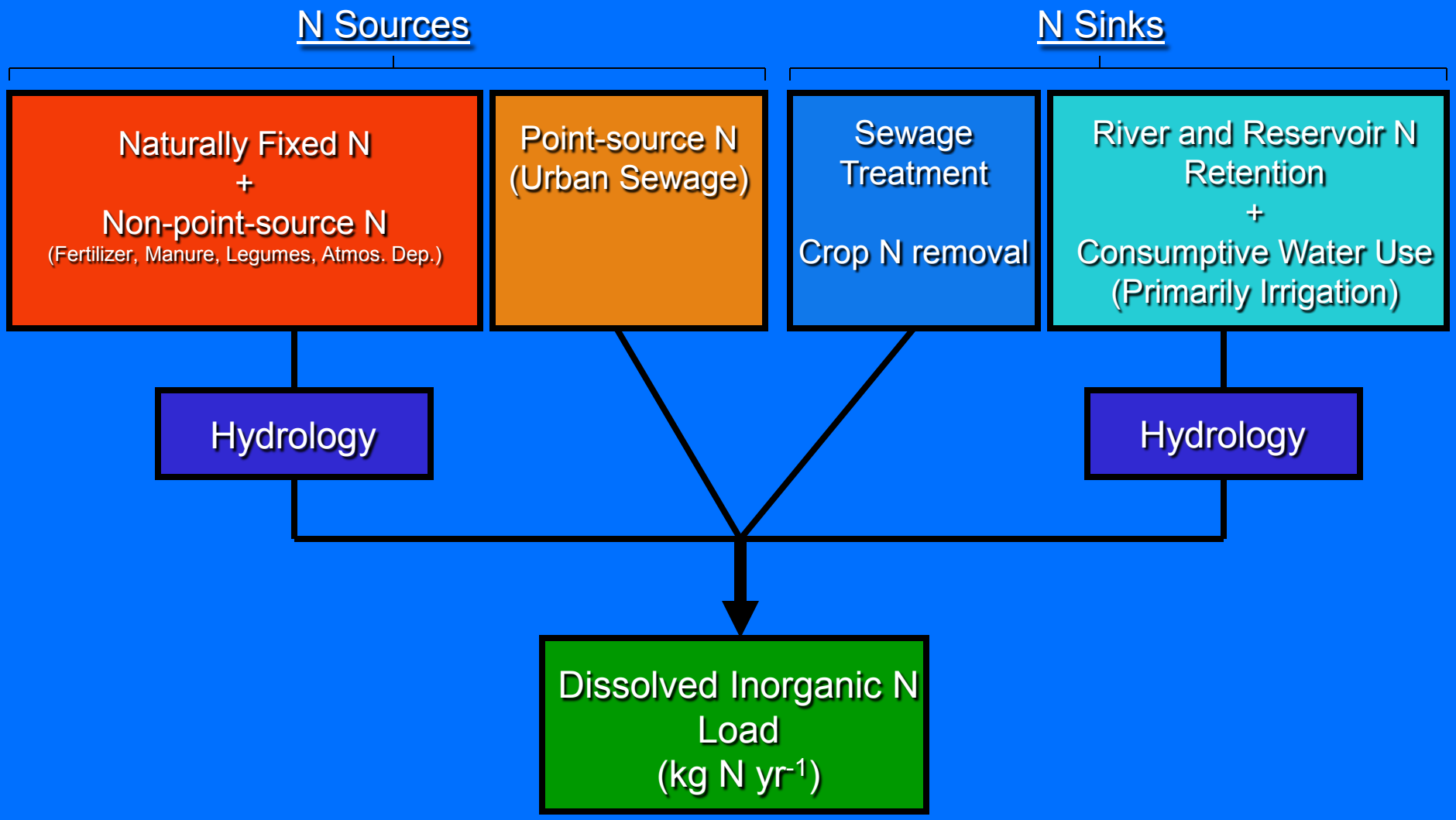


Sobota et al. (2009), Biogeochemistry

Modeling of riverine N export: Global Nutrient Export from Watersheds (NEWS) model

NEWS model



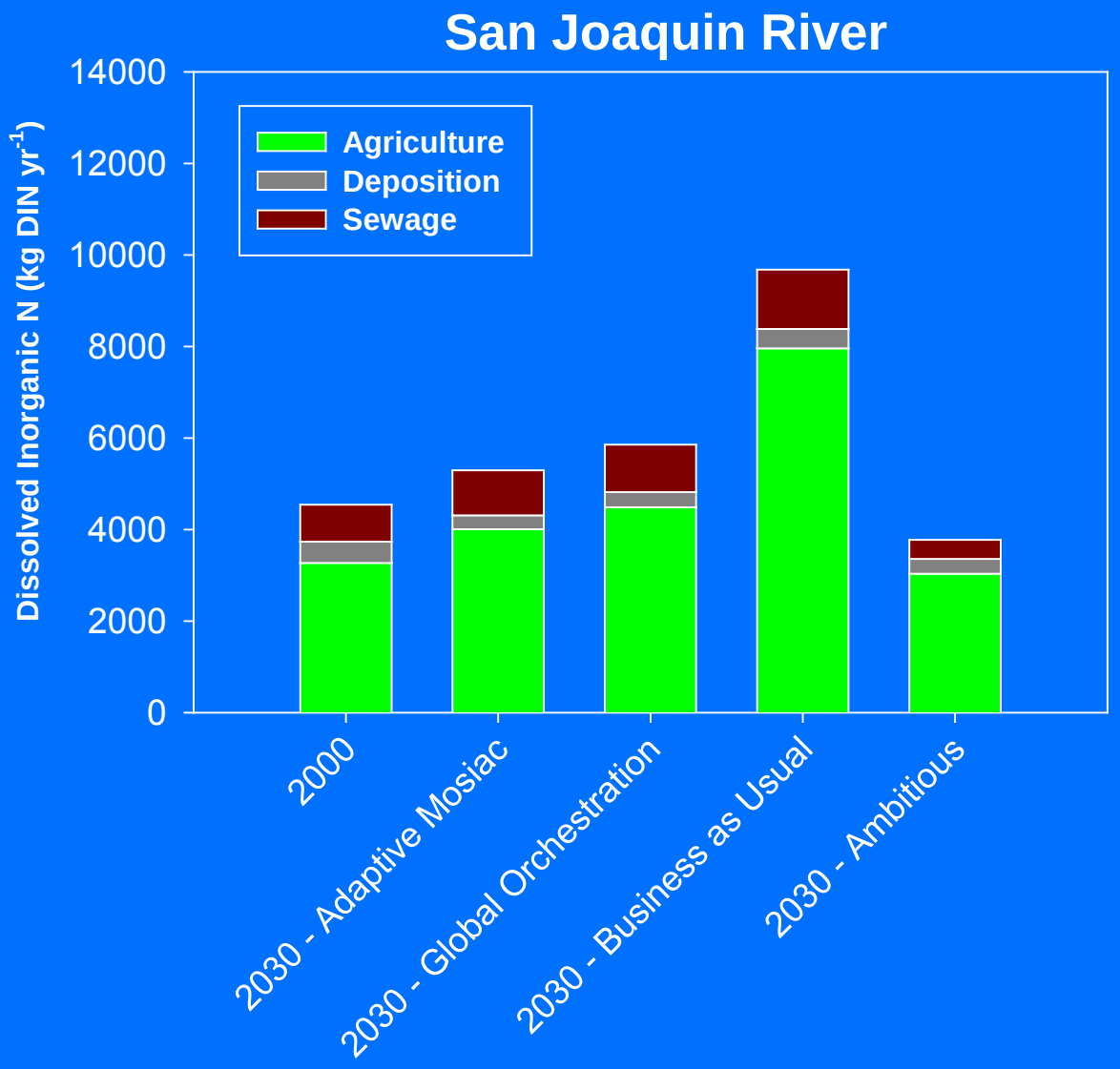
(Mayorga et al. 2010, McCrackin et al., in revision)

Scenario drivers – national scale

	2000	2030 Adaptive Mosaic	2030 Global Orch.	2030 Business as Usual	2030 Ambitious (25% reduction)
Population (million people)	297	370	375	375	375
Fertilizer recovery efficiency (%)	48	63	57	48	70
N in human excretion (kg N/person)	6.4	7.3	8.0	8.0	6.4
N removed by WWTP (%)	61	66	70	61	80

Scenarios from the McCrackin et al. (in revision)

Future DIN loads



Scenarios from the McCrackin et al. (in revision)

Take home messages

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Take home messages

- Synthetic fertilizer, manure, and deposition account for >80% of annual anthropogenic N inputs
- Net N inputs from human activities and runoff explain >70% of variance in N concentrations
- Export of watershed N inputs scales exponentially with runoff
- Current practices could more than double DIN export from the San Joaquin River by 2030

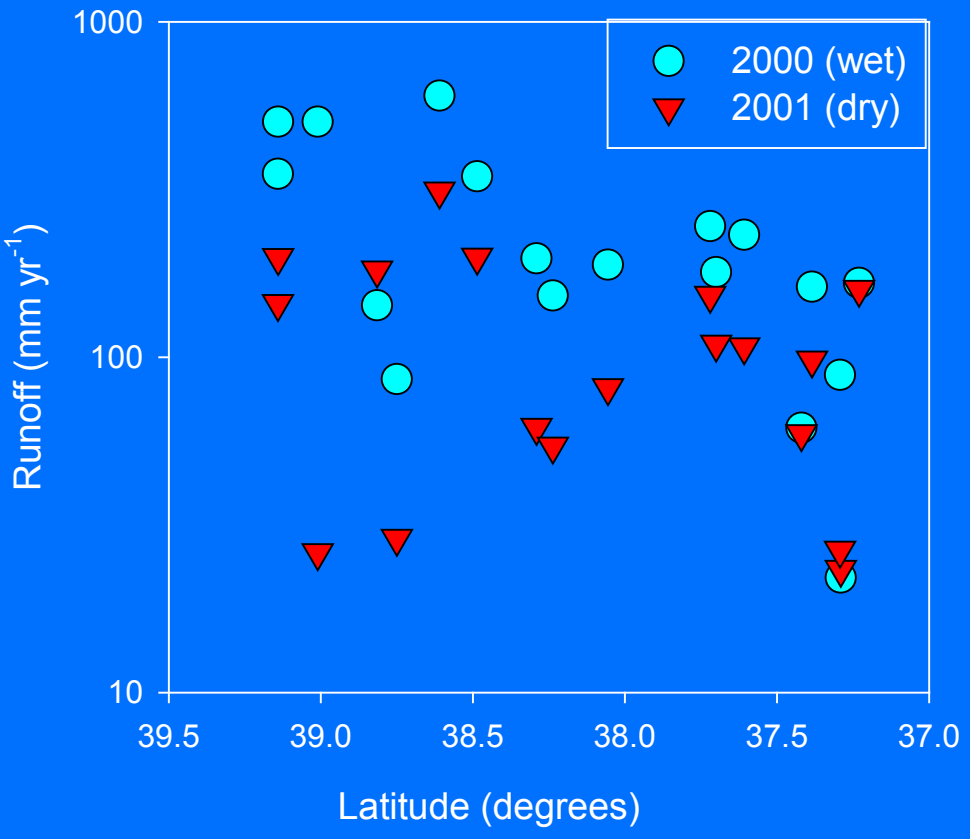
Acknowledgements

- Funding provided by California Sea Grant (award number RSF8) and the USGS 104b Program
- Randy Dahlgren, UC-Davis
- Charlie Kratzer, USGS California Water Science Center

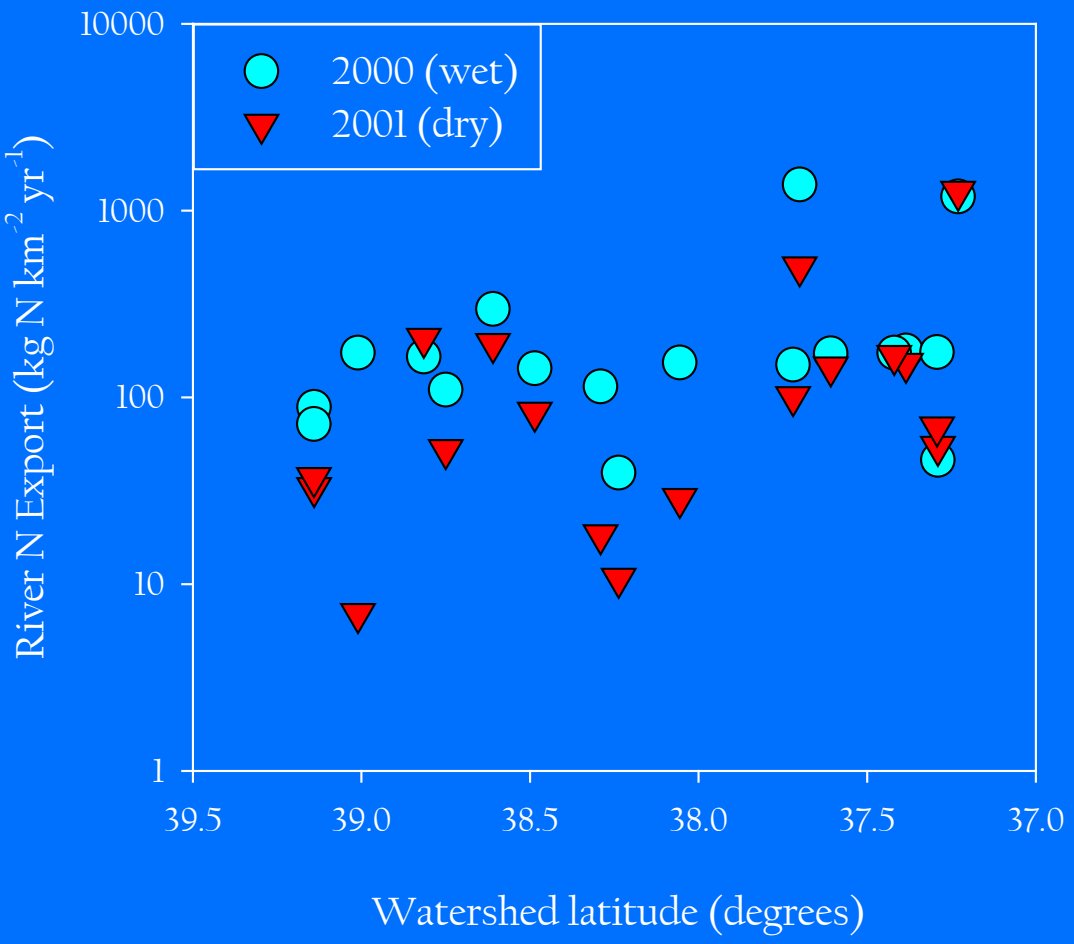

Questions?
sacramentofordemocracy.org

Additional Information

Temporal Pattern - Runoff

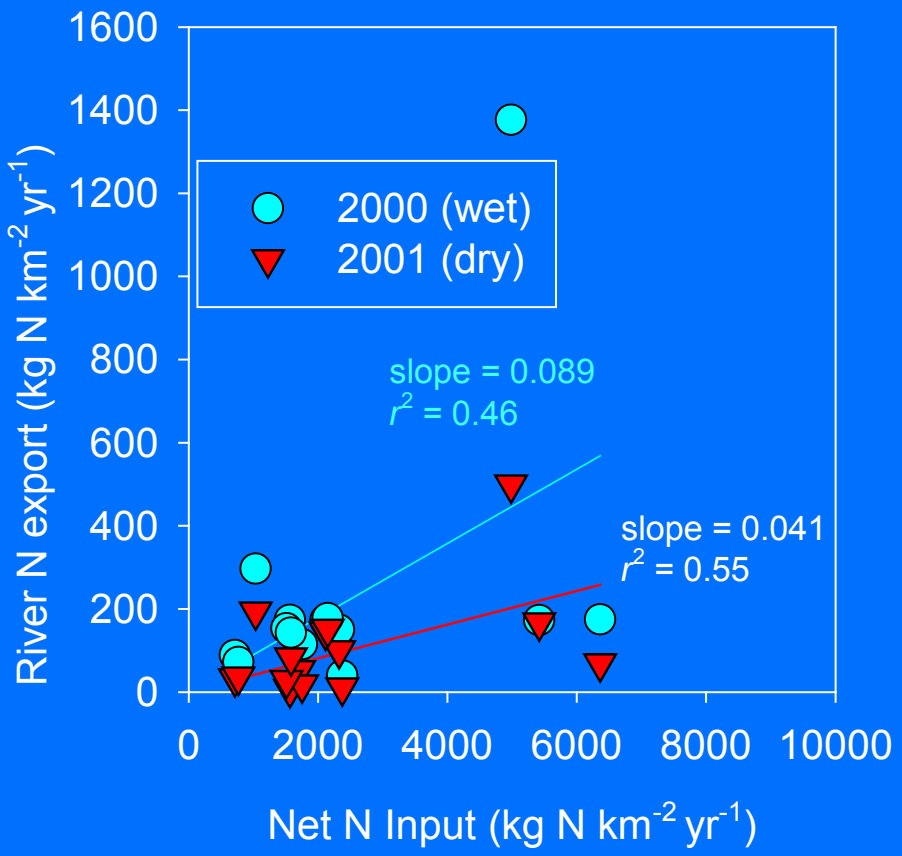


Temporal Pattern - Export

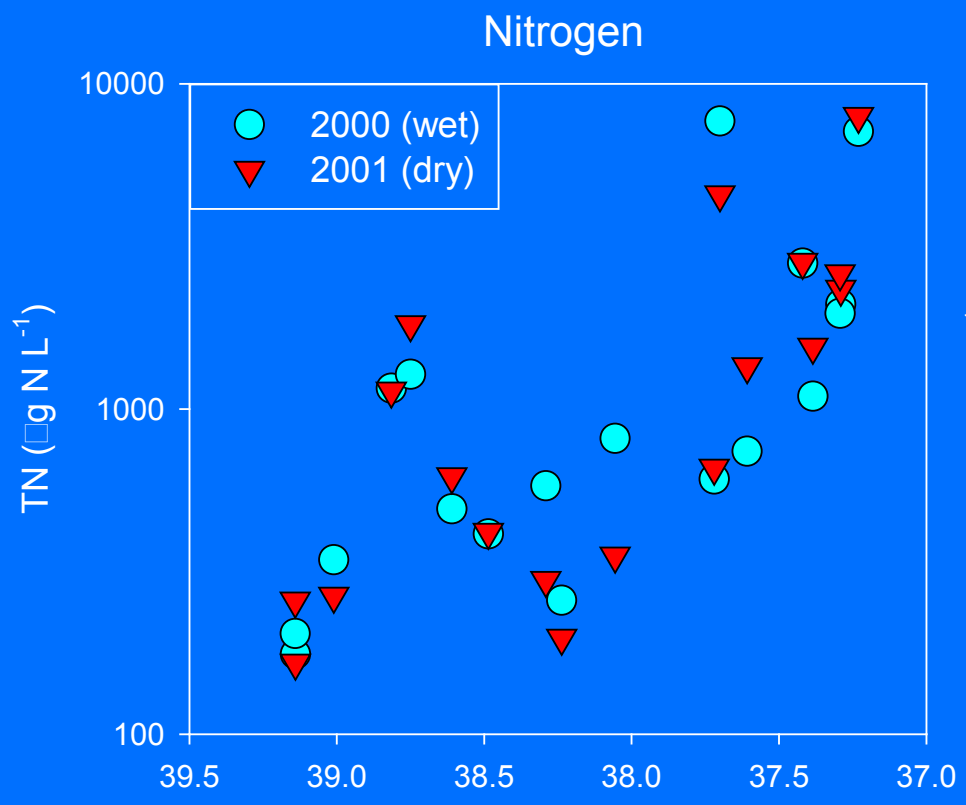


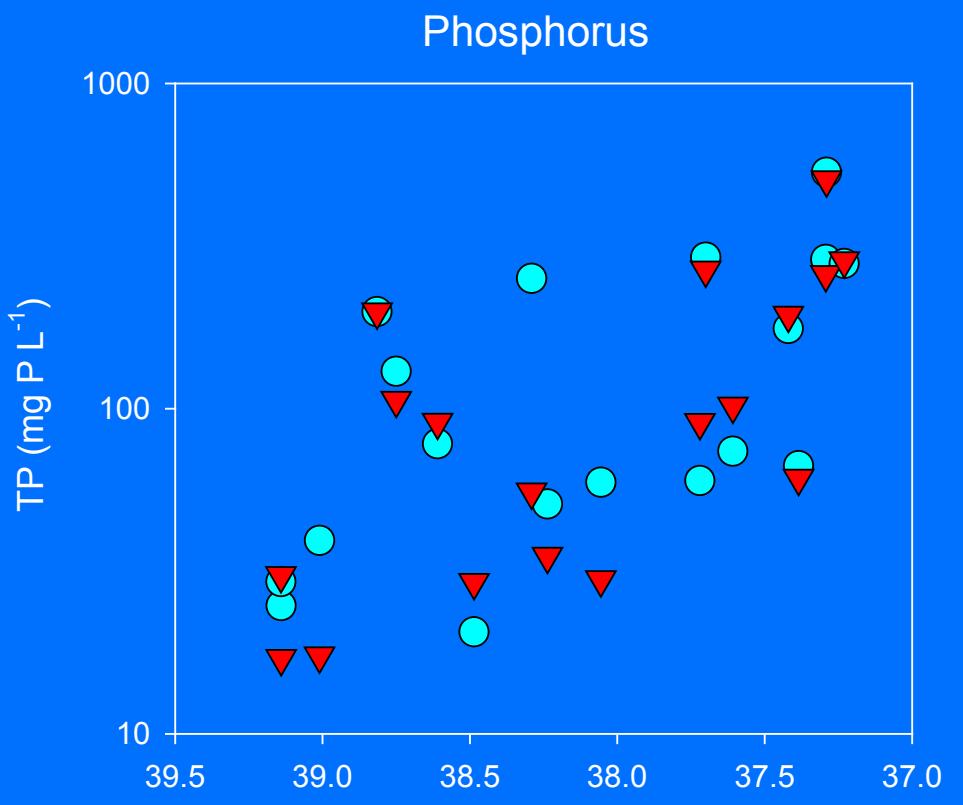
*18 basins with multi-year data

Temporal Patterns: Import-Export



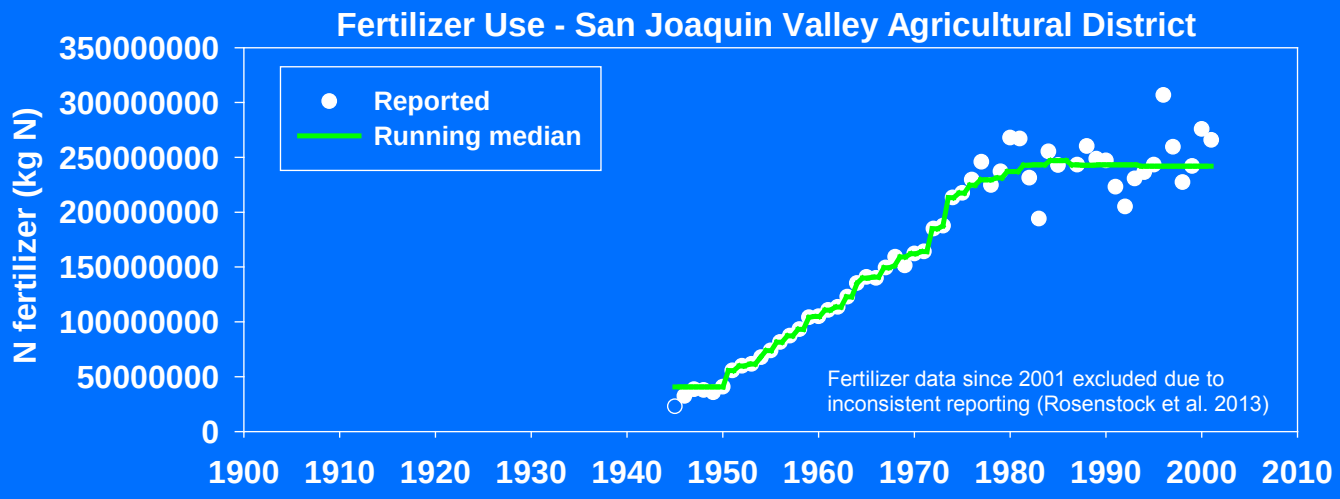
Temporal Pattern - Concentration





Latitude (degrees)

Long-term trends



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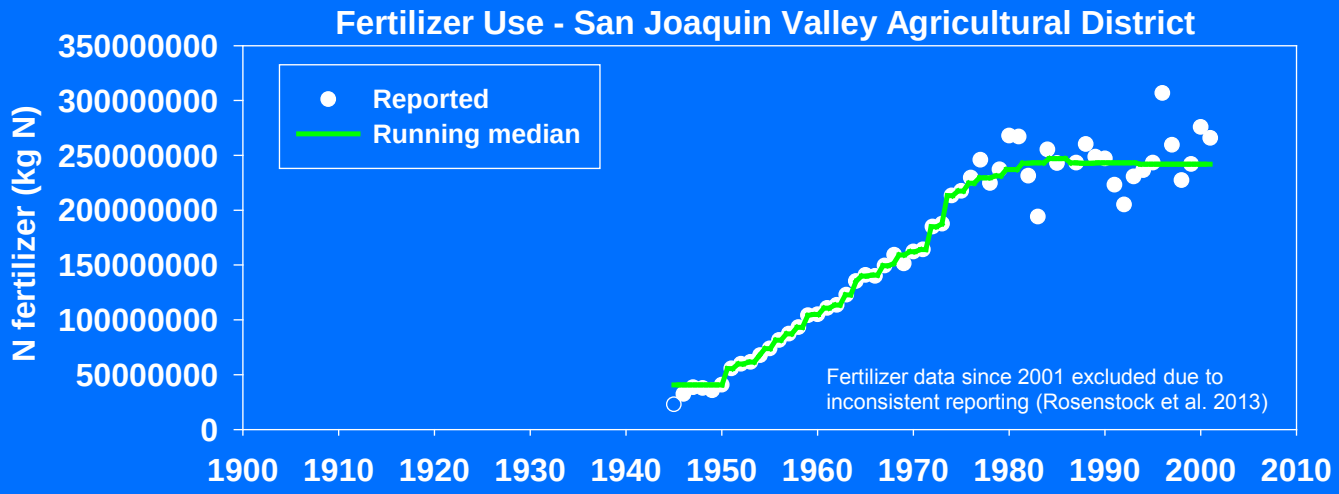

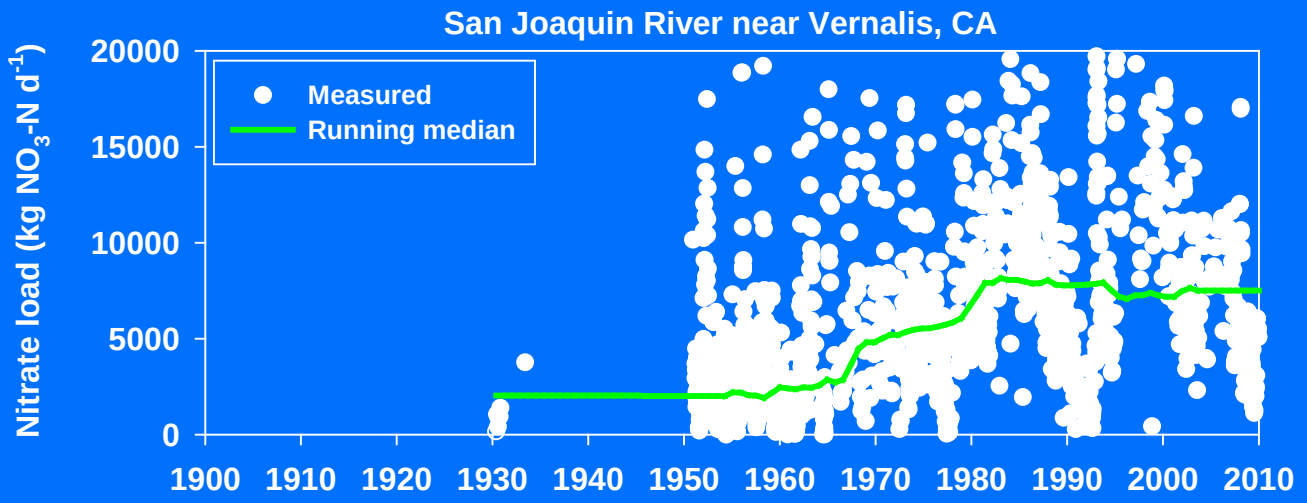

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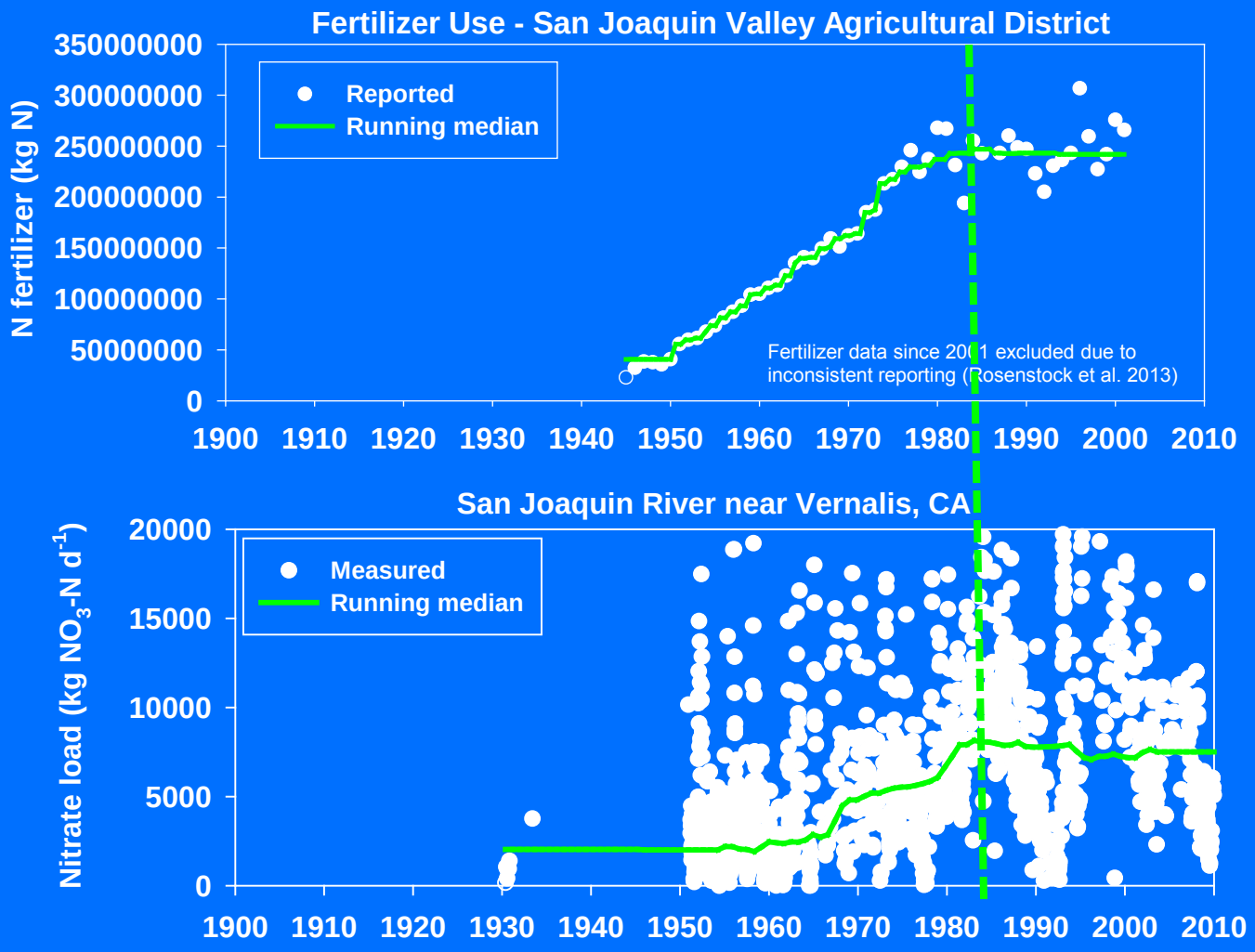
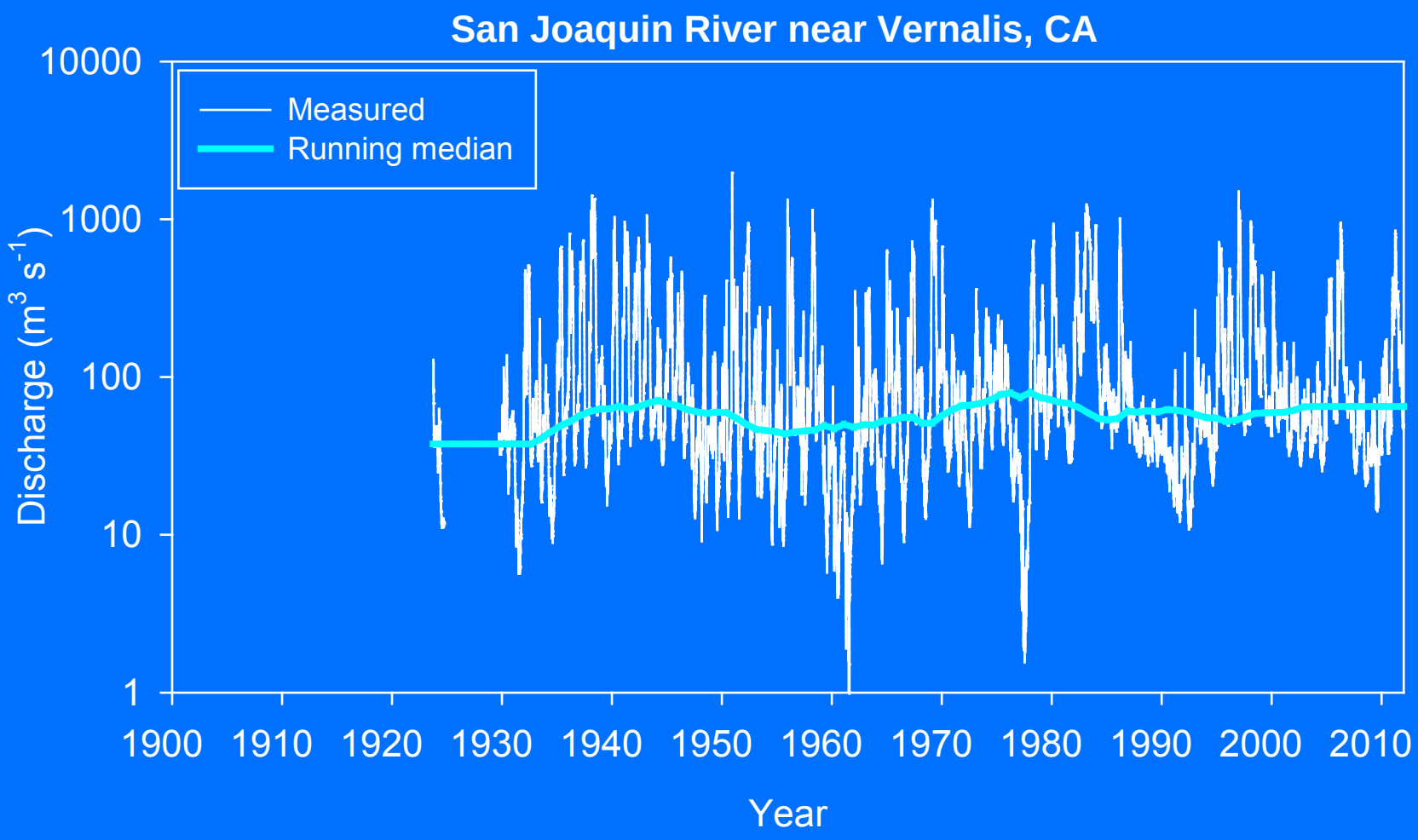
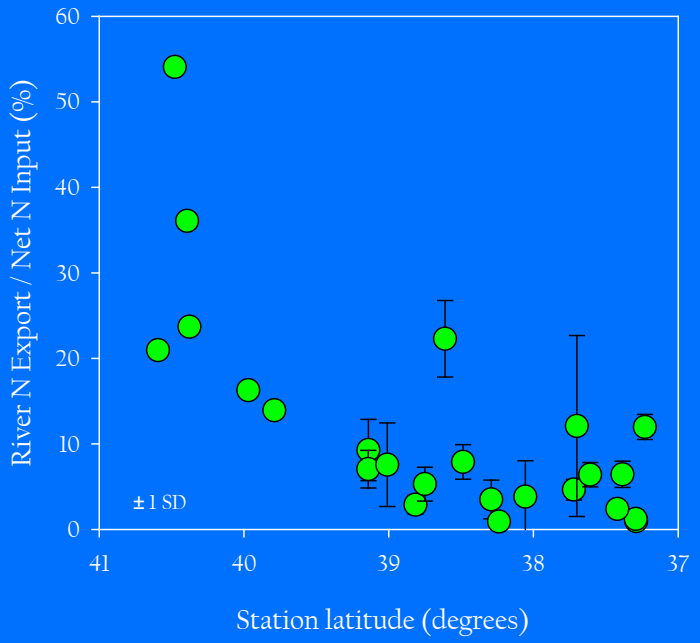
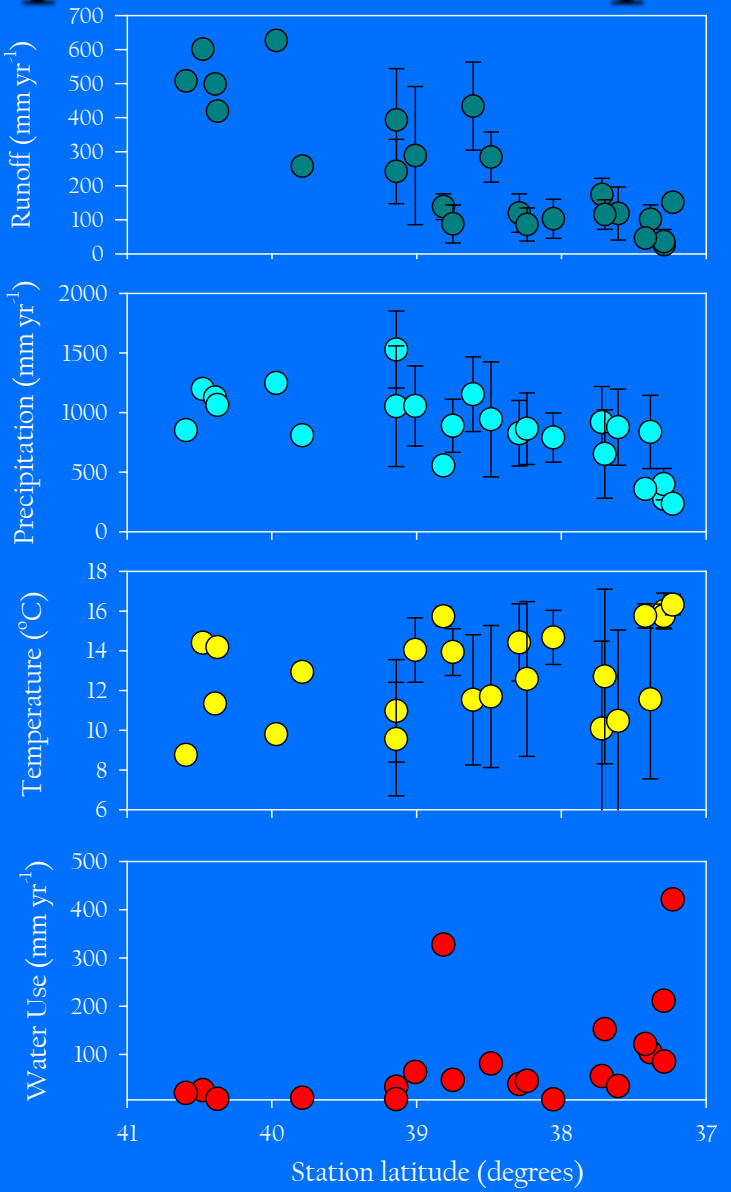


River flow


San Joaquin River near Vernalis, CA
Measured
Running median
Discharge (m3 s-1)
10000
1000
100
10
1
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

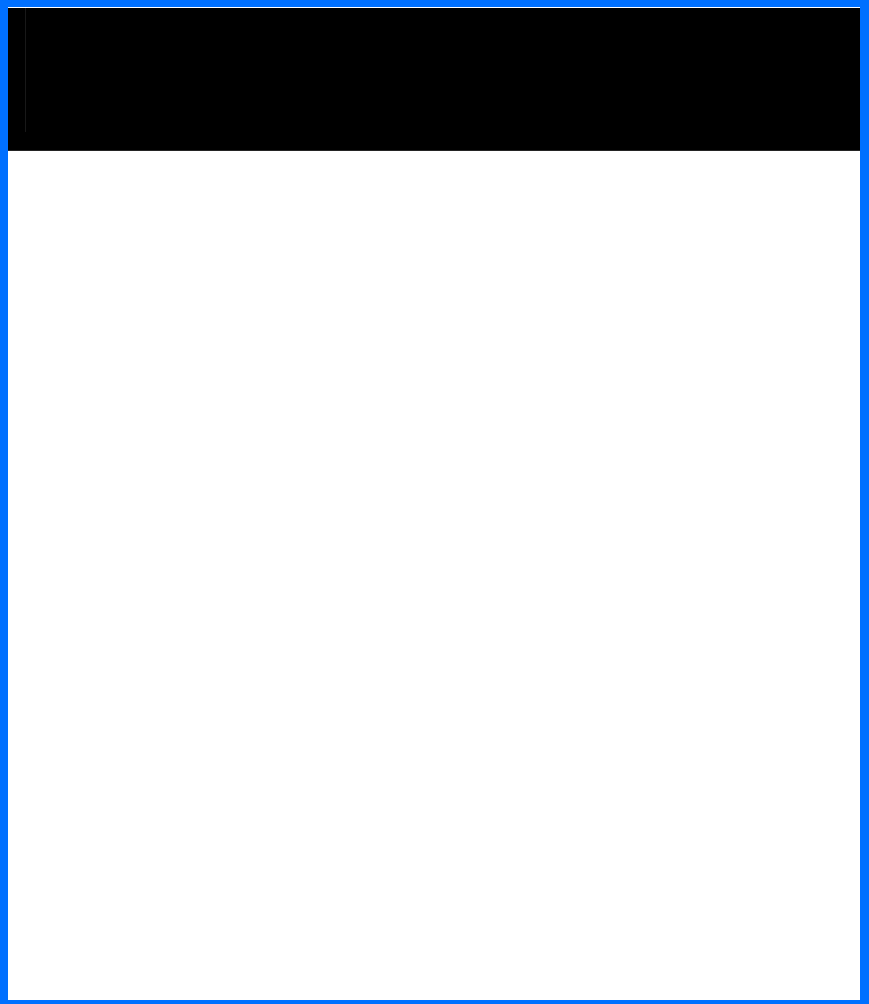
Fractional export of N inputs



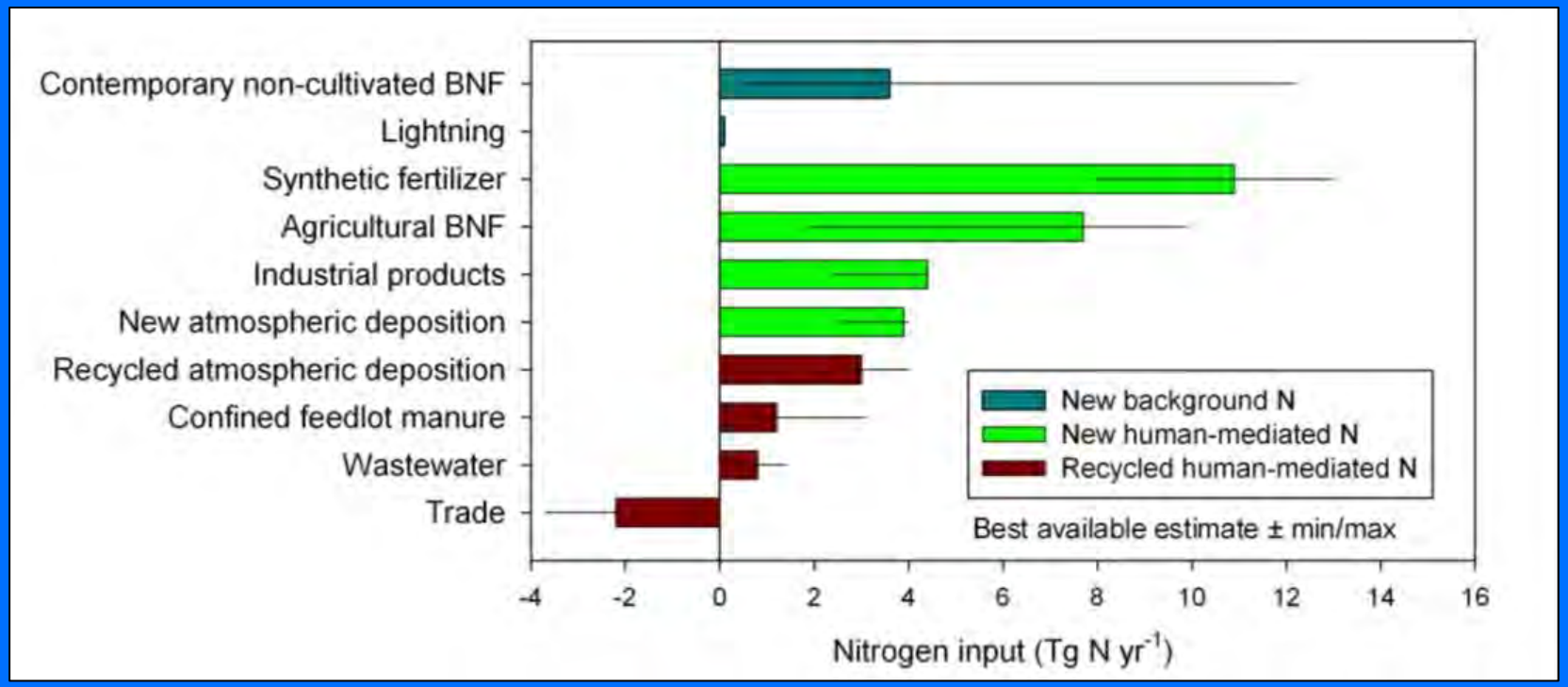


Natural N-fixation

- Average of two methods:
  - Vegetation classes (Cleveland et al. 1999)
  - Baseline N-fixation in soils (Boyer et al. 2002) and fixation by *Ceanothus* spp. in conifer forests (Busse 2000)



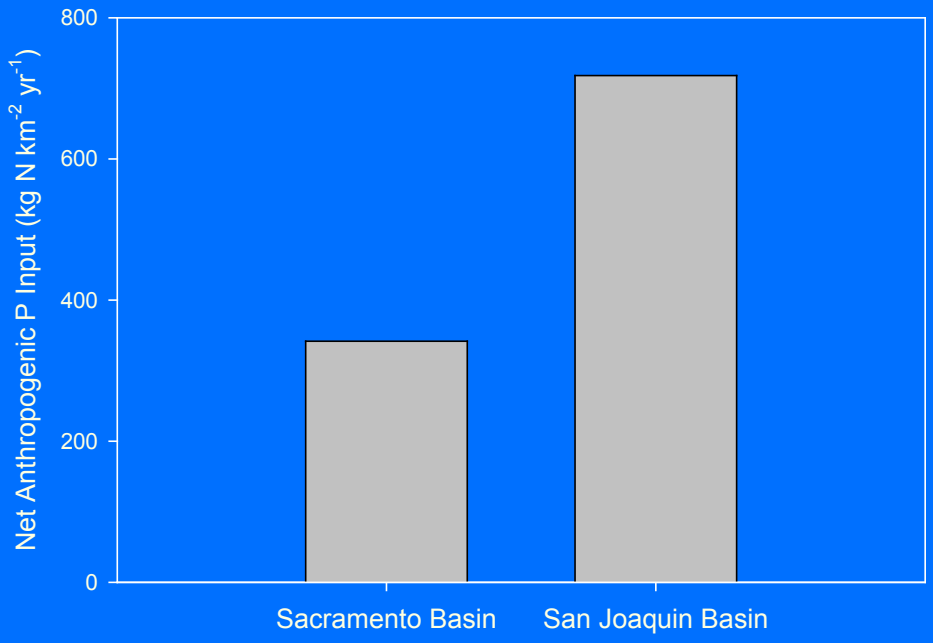
Reactive N in the United States



54 total, individual N input estimates
BNF: biological nitrogen fixation
1 Tg = 1 x 10^{12} g or 2.2 x 10^{9} lbs

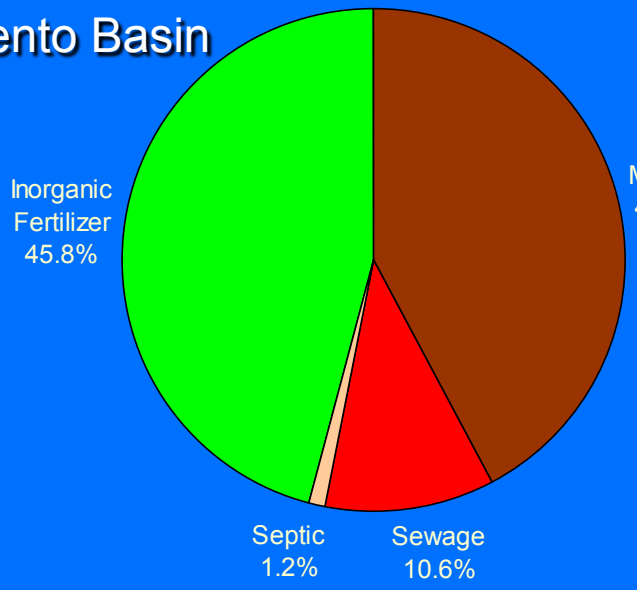
Sobota et al. 2013, Frontiers in Ecology and the Environment

Anthropogenic P Input

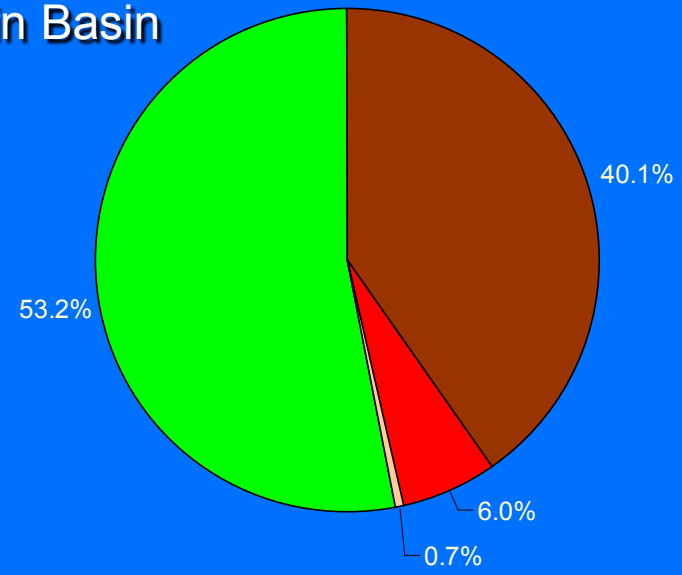


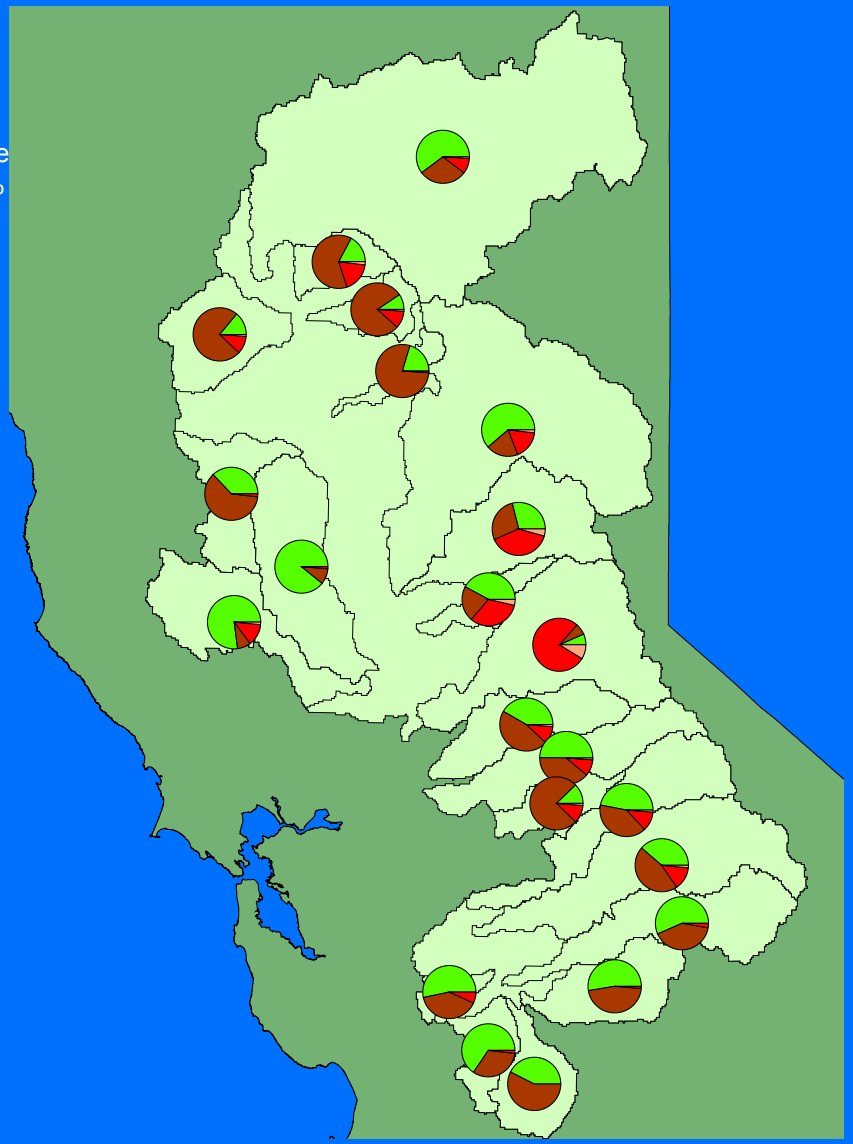
Proportion of P inputs

Sacramento Basin

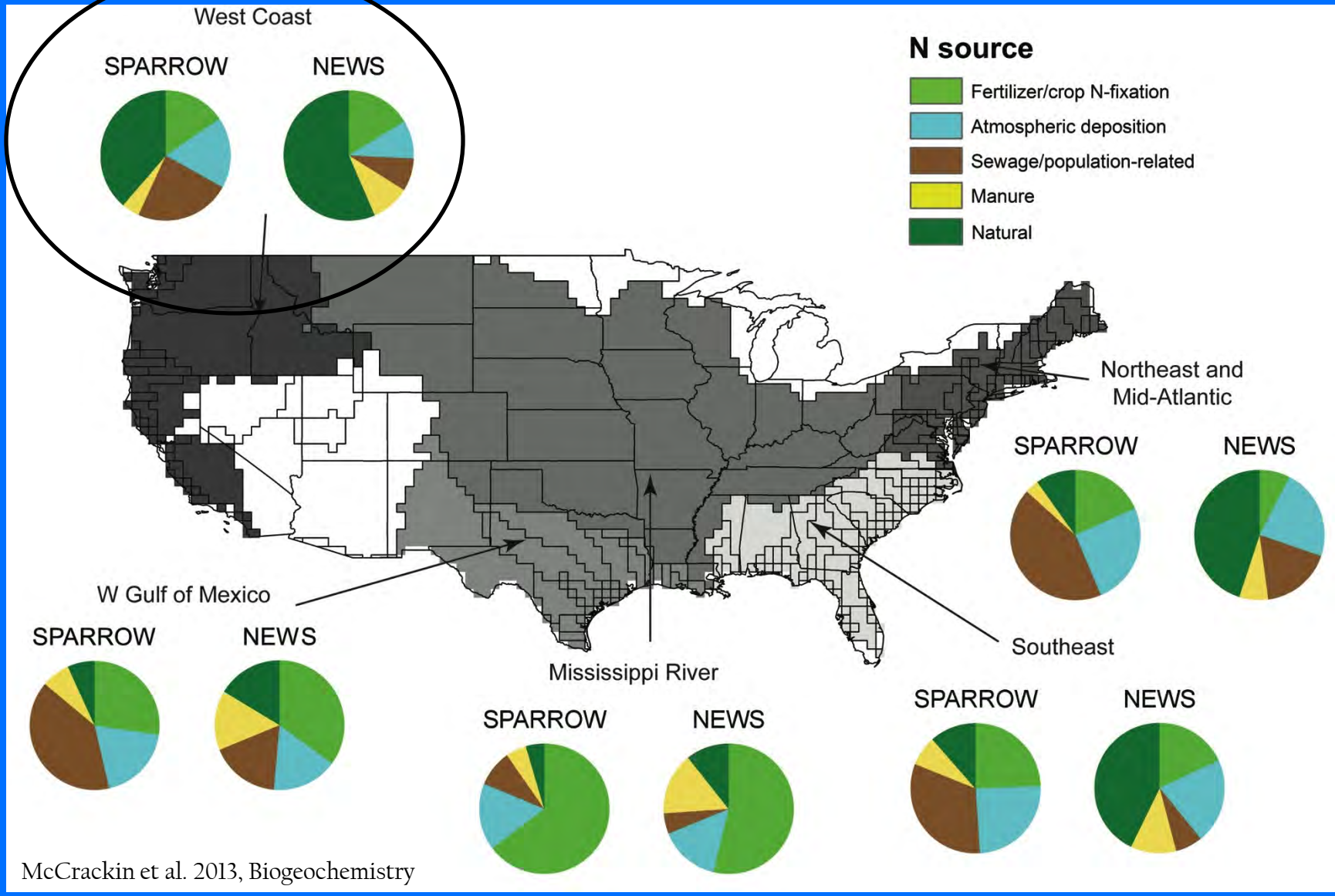


San Joaquin Basin





NEWS-SPARROW comparison



McCrackin et al. 2013, Biogeochemistry

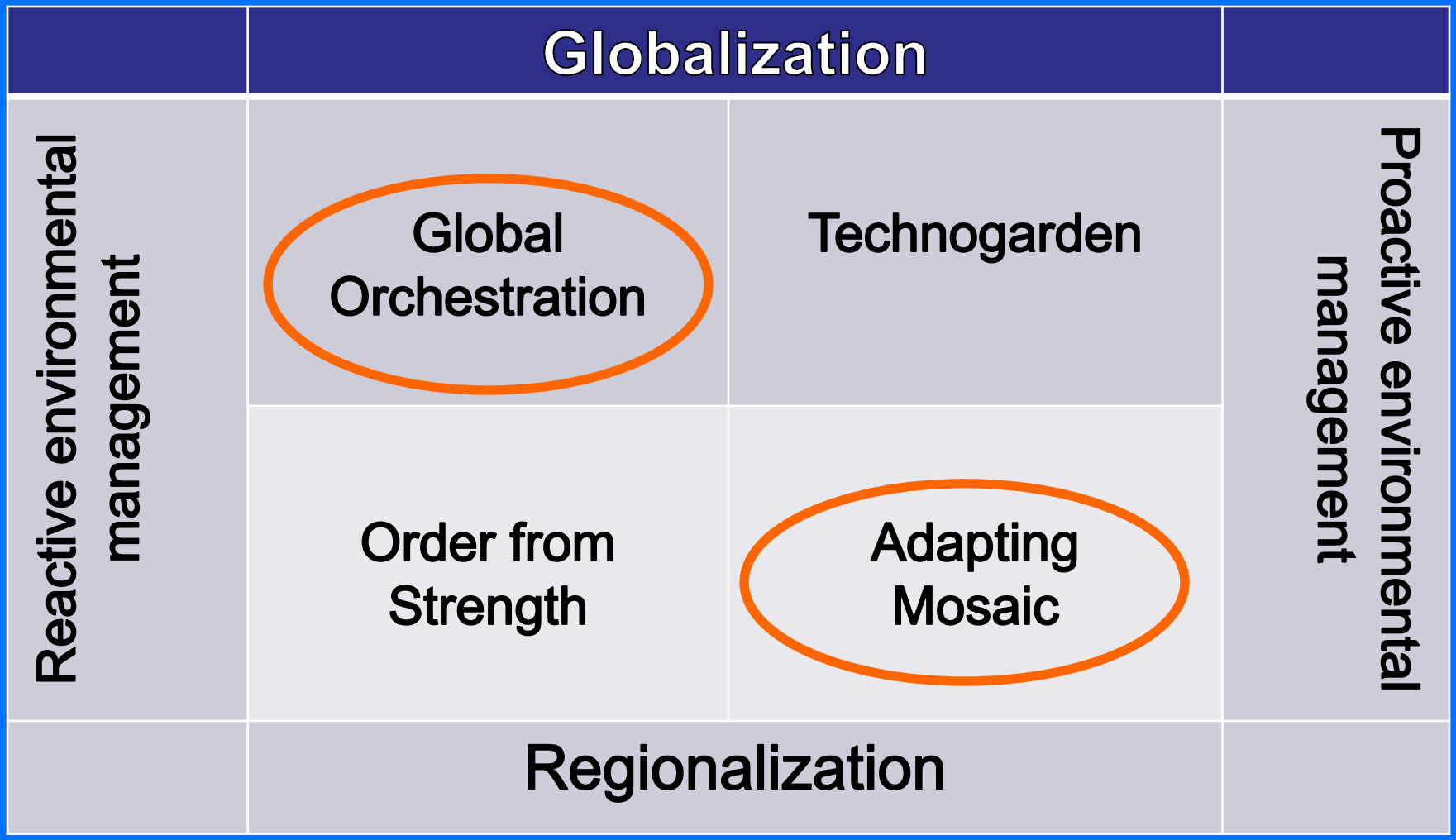
Agricultural N-fixation

Centralized Sewage Nutrients

Septic System Nutrients

Crop Nutrient Harvest

Millennium Ecosystem Assessment scenarios



Millennium Ecosystem Assessment 2005; Seitzinger 2010